

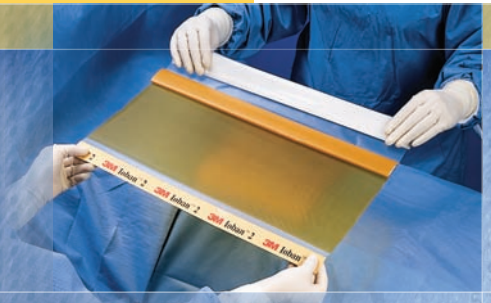
3M™ DuraPrep™ Surgical Solution

(Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w)

Patient Preoperative Skin Preparation

3M™ Steri-Drape™

Incise Drapes



Safety & Efficacy Data



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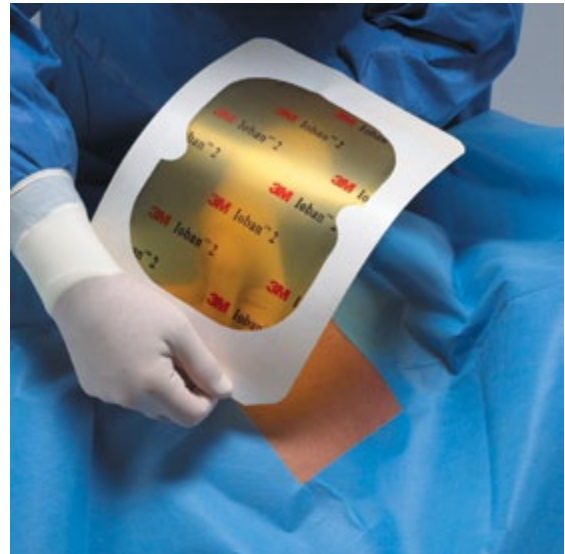
3M™ Steri-Drape™ Incise Drapes

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* The clinical significance of *in vitro* data is unknown.

3M™ DuraPrep™ Surgical Solution

(Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w)

Patient Preoperative Skin Preparation

Using the power of povacrylex, DuraPrep solution gives you effective antimicrobial kill in a single, painted coat – along with significantly greater drape adhesion. What's more, it keeps bacterial counts low at least 48 hours* against resident bacteria after blood and saline challenge. Can your surgical patient prep say as much?

* Following ASTM E1173

Preclinical Studies

Below is a list of some of the preclinical studies conducted to verify the safety of 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation

Single Dose Toxicity

- Acute Dermal Toxicity Study
- Acute Oral Toxicity Study

Repeat Dose Toxicity

- Two 2-Week Dermal Toxicity Studies (2 species)
- 28-Day Dermal Toxicity Study
- Sensitization Study

Mutagenicity Studies

- Chromosome Aberration Study
- Mouse Lymphoma Assay Study

Human Safety Studies

Following are summaries of 5 human studies conducted in support of the safety of DuraPrepsolution.

STUDY 1

Human Repeat Insult Patch Test (HRIPT)

In 2002, 204 subjects received 9 consecutive applications of DuraPrep solution to the upper arm over a 3-week period and two 48-hour challenge doses after a 10–14 day rest period. After the test products dried on application, occlusive patches were applied. Each patch was in contact with skin for 48 ± 2 hours after each application or 72 ± 2 hours if over the weekend. During the induction phase, several subjects exposed to DuraPrep solution exhibited scattered mild inflammatory responses. Additionally, in a few subjects, some of the responses became sufficiently irritated to require moving the test materials to new skin sites. DuraPrep solution exhibited no indication of potential sensitization following challenge application to both the original and naive skin sites.

STUDY 2

Human Repeat Insult Patch Test (HRIPT)

Each of the 240 volunteers received nine induction applications (three per week for three weeks) of 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation on the skin of the upper arm in a study conducted in 1988. The applications were covered with 3M™ Tegaderm™ Transparent Dressing. The challenge application was administered 12–24 days after the final induction application. All induction applications were graded 24 hours after dressing removal and challenge sites were graded at 48 and 96 hours post-dressing removal. No evidence of contact sensitization was observed in any of the 209 volunteers who completed the study. Mild erythema was seen on 55 volunteers. In 20 volunteers, occasional papular responses were experienced during the induction phase. These results indicate that DuraPrep solution does not have significant sensitization potential.

STUDY 3

21-Day Cumulative Irritation (HCIPT)

In 2002, DuraPrep solution, DuraPrep solution without Iodine, Betadine® Solution (1% available iodine), 70% isopropyl alcohol and other appropriate controls were delivered to a 1-inch² area via pipette, allowed to dry and covered with occlusive patches on each of 21 consecutive days on the backs of 32 volunteers. Each patch was in contact with skin for 24 ± 2 hours.

The Base 10 Cumulative Irritation Score for DuraPrep solution was 307.7, Class 3 (possibly mild in normal use). This was the same category as Betadine solution (Score: 345.3). As expected, the presence of iodine in the test solutions increased the potential for cumulative skin irritation to occur.

Since DuraPrep solution is indicated as a single use, pre-operative skin preparation the irritancy potential in actual use would be expected to be low and similar to Betadine solution.

STUDY 4

21-Day Cumulative Irritation (HCIPT)

In 1988, DuraPrep solution and isopropyl alcohol were applied to six sites, occluded (with 3M™ Steri-Drape™ Surgical Incise Drape or Tegaderm transparent dressing) or not occluded on each of 12 volunteers. Tegaderm dressing alone and alcohol alone were used as controls. Exposure was daily for five days per week for three weeks. Skin erythema was assessed. DuraPrep solution alone (unoccluded) elicited no cumulative irritation. When DuraPrep solution was occluded with Steri-Drape incise drape, however, minimal or slight cumulative irritation was seen. This slight increase in irritation was most probably due to skin stripping with the daily removal of Steri-Drape incise drape. Alcohol alone showed mild cumulative irritation over 21 days. Daily applications of alcohol would be expected to cause some irritation from the defatting and drying nature of repeated applications.

STUDY 5

21-Day Cumulative Irritation (HCIPT)

DuraPrep solution was tested in seventeen (17) female Caucasian subjects for cumulative irritation in a study conducted in 1988. Exposure was daily, five days per week for a period of three weeks. The prepped sites were allowed to dry and then occluded. Each site was covered with a non-porous adhesive, Tegaderm transparent dressing and then covered with a Webriil® pad. Also tested were control materials and Betadine ointment. Skin erythema was assessed. All subjects showed low to no irritation to DuraPrep solution and Betadine ointment. One of the two lots of DuraPrep solution tested had a cumulative irritation index score of 0.0/630, indicating no irritation. The second lot of DuraPrep solution had a cumulative irritation index score of 7.1/630, indicating transient irritation. These study results indicate that DuraPrep solution would be considered to have a low order of cumulative irritation potential.

Helpful Hints

The number of bacteria represented by log reduction is dependent upon the number of bacteria present initially (baseline). For example, if the baseline is 4 logs and the reduction is 3 logs, only 1 log of bacteria remains which is equal to 10 colony forming units (CFUs). However, if the baseline is 6 logs and the reduction is 3 logs, 3 logs of bacteria remain which is 1000 CFUs. When discussing bacteria counts on skin, the unit of measure is logs/square centimeter (cm). 1 inch is equal to 2.54 centimeters. So a squared cm (cm²) is equal to 0.155 squared inches. Studies have shown that foreign material, such as an implant, decreases the infectious dose of staphylococci from more than 10⁶ (>6 logs) to less than 10² (< 2 logs). So even 2 logs of bacteria remaining on the skin of a patient can increase the risk of SSI and can be a significant risk for patients receiving an implant because of the reduced number of bacteria required for infection development.¹

Logs	No of bacteria	Log reduction	% reduction of bacteria
1	10	1	90
2	100	2	99
3	1000	3	99.9
4	10,000	4	99.99
5	100,000	5	99.999
6	1,000,000	6	99.9999

Efficacy Studies Conducted

The efficacy of 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation has been verified in many studies.

The studies included were conducted in the laboratory (*in vitro* studies), on healthy human volunteers (*in vivo*), or on clinical patients. Summaries of each study are provided.

► **Minimum Bactericidal Concentration of Iodine in 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation**

Minimum Bactericidal Concentration (MBC) studies are conducted to establish the minimum concentration of an active ingredient required to kill the test organism. The result is expressed as the concentration (in µg/mL) required to kill a specific bacterial isolate or as a range of concentrations that kill all of the strains or isolates tested. MBCs are more commonly used to test antibiotics which, when ingested or injected into the body, become diluted and must be effective against bacteria at low concentrations. Comparing MBCs among antibiotics can provide a relative indication of effectiveness. The concentration of active ingredient that is available for bacterial kill on skin is higher compared to that of antibiotics. The MBC of iodine in DuraPrep solution ranges from 0.125–16 µg/mL, which is a small fraction of the in-use concentration of 0.7% or 6020 µg/mL available iodine.

Table 1

Microorganism	Lab Strains		Clinical Isolates	
	N	MBC Range (µg/mL)	N	MBC Range (µg/mL)
<i>Acinetobacter</i> sp.	25	0.25–2	25	0.25–4
<i>Bacteroides fragilis</i>	20	0.25–2	31	0.25–8
<i>Haemophilus influenzae</i>	25	0.125–2	25	0.125–1
<i>Enterobacter</i> sp.	25	0.5–2	25	0.5–2
<i>Escherichia coli</i>	25	0.5–1	25	0.5–2
<i>Klebsiella</i> sp.	25	0.25–1	25	0.5–2
<i>Pseudomonas aeruginosa</i>	25	0.5–8	25	1–4
<i>Proteus mirabilis</i>	25	0.5–2	25	0.5–4
<i>Serratia marcescens</i>	25	0.5–2	25	0.25–4
<i>Staphylococcus aureus</i> including MRSA	25	0.5–2	25	0.5–4
<i>Staphylococcus epidermidis</i> including MRSE	25	0.125–2	25	0.25–1
<i>Staphylococcus hominis</i>	12	0.5–2	38	0.25–4
<i>Staphylococcus haemolyticus</i>	6	0.5–1	44	0.5–2
<i>Staphylococcus saprophyticus</i>	5	1–2	45	0.5–2
<i>Micrococcus luteus</i>	25	0.5–4	25	0.5–4
<i>Streptococcus pyogenes</i>	25	0.25–16	25	0.5–8
<i>Enterococcus faecalis</i> including VRE	25	0.5–4	25	1–4
<i>Enterococcus faecium</i> including MDR	25	1–4	25	1–4
<i>Streptococcus pneumoniae</i>	25	0.125–8	25	0.25–4
<i>Candida</i> sp.	25	1–16	25	2–16
<i>Candida albicans</i>	25	2–8	25	2–8

For antimicrobials, the value of MBC studies is to confirm the broad spectrum kill of the agent via the testing of many bacterial strains/isolates.

Purpose

In an independent study conducted in 2002 at one laboratory, MBCs were measured for DuraPrep solution against 1051 bacterial isolates. The vehicle control and reference product were tested against 211 isolates of the organisms listed below. The MBC was defined as the lowest concentration of iodine (in µg/mL) that resulted in complete kill of the test organism.

Method

MBCs were tested at 30-minutes post-inoculation against clinical isolates and laboratory American Type Culture Collection, (ATCC) strains for a total of 50 for each microorganism.

Results

The results are presented in Table 1. DuraPrep solution demonstrated antiseptic activity against all organisms tested.

► Minimum Bactericidal Concentration of Iodine in 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation and Povidone-Iodine Tincture

Purpose

Minimum bactericidal concentrations (MBCs) were determined and compared for DuraPrep solution, an alcohol/copolymer control (copolymer vehicle without iodine/sodium iodide), and tincture of povidone iodine (0.7% available iodine in isopropyl alcohol, 74% w/w) in a study conducted in 1995. The MBC was defined as the lowest concentration of iodine that resulted in complete kill of the test organism at each time point.

Method

MBCs were determined against 31 test organisms (both clinical and ATCC isolates, see Table 2) at 1, 5, 15 and 30 minutes post-inoculation.

Results

The MBCs of DuraPrep solution and povidone-iodine tincture were found to be equivalent against each test organism at each time point tested (i.e., within the plus or minus one two-fold dilution error of the test method). MBCs ranged from 0.25 µg/mL to 16 µg/mL, with certain strains of *Staphylococcus aureus* and *Enterococcus* requiring the highest concentration and/or longest contact time to achieve complete kill. At the concentrations tested, the DuraPrep solution polymer vehicle did not exhibit antimicrobial activity against any of the test organisms at any time point.

Table 2

Organisms Tested	Types
<i>Enterobacter cloacae</i>	ATCC Isolate
<i>Enterococcus faecalis</i>	5 Clinical Isolates 2 ATCC Isolates
<i>Enterococcus faecium</i>	2 Clinical Isolates
<i>Escherichia coli</i>	ATCC Isolate
<i>Klebsiella pneumoniae</i>	ATCC Isolate
<i>Proteus mirabilis</i>	Mouse Isolate
<i>Pseudomonas aeruginosa</i>	ATCC Isolate
<i>Burkholderia cepacia</i>	ATCC Isolate
<i>Serratia marcescens</i>	ATCC Isolate
<i>Staphylococcus aureus</i>	2 ATCC Isolates 7 Methicillin-resistant Clinical Isolates
<i>Staphylococcus epidermidis</i>	2 ATCC Isolates
<i>Staphylococcus haemolyticus</i>	ATCC Isolate
<i>Staphylococcus hominis</i>	ATCC Isolate
<i>Staphylococcus</i> sp.	Methicillin-resistant Clinical Isolate
<i>Streptococcus pneumoniae</i>	ATCC Isolate

► Minimum Bactericidal Concentration of Iodine in 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation and Povidone-Iodine

Purpose

The purpose of this study (completed in 1997) was to determine the minimum concentration of DuraPrep solution, an alcohol/copolymer control, and Betadine® solution (1% available iodine) required to completely kill the test organisms after a 30-minute contact time.

Method

Diluted antiseptics were added to the wells of 96-well microtiter plate and serial two-fold dilutions of the antiseptics were made with sterile deionized water. Plates were inoculated with the test organism at a concentration of approximately 5 x 10⁵ CFU/mL and were incubated for 30 minutes. Following the 30-minute contact time, aliquots were transferred from the antiseptic plate to a microtiter plate containing a suitable liquid growth medium. Following overnight incubation, the plates were examined for growth. Ten isolates of six bacterial strains (*Burkholderia cepacia*, *Enterococcus faecalis*, *Escherichia coli*, *Staphylococcus epidermidis*, methicillin-sensitive *Staphylococcus aureus* (MSSA), and methicillin-resistant *Staphylococcus aureus* (MRSA) were tested. Fresh clinical isolates were used when available.

S. aureus (ATCC 6538) was run as a control strain with each set of isolates evaluated to assess the reproducibility of the MBC method used in this study.

Results

The MBC determinations on the control strain confirmed that the test method was reproducible, with MBCs routinely being within one two-fold dilution of one another (the accepted error for microdilution methods), both within duplicate samples and between repeated tests.

The MBCs determined for each species varied although most isolates had MBCs that were within one two-fold dilution of one another. When available, clinical isolates were run preferentially to determine the degree of variability within these strains.

There was no discernible difference in MBCs between clinical and ATCC isolates. The greatest degree of variability was seen against isolates of *B. cepacia*. The MBCs for Betadine solution against this organism ranged from 2 µg/mL to 16 µg/mL (3 two-fold dilution stops) and for DuraPrep solution ranged from 8 µg/mL to >16 µg/mL (2 two-fold dilutions). For most other species, the MBCs for Betadine solution and DuraPrep solution differed by only one or two two-fold dilutions.

The MBCs of DuraPrep solution were usually one to two two-fold dilution stops higher than the MBCs of Betadine solution against the same organism (see Table 3). Time-kill studies using undiluted product dried onto filters demonstrated similar efficacy for DuraPrep solution and Betadine solution against all test organisms, indicating that small differences

in MBCs observed between DuraPrep solution and Betadine solution do not translate to a difference in kill rates. All MBCs observed were well below the in-use concentration of each product (6020 µg/mL for DuraPrep solution and 10,000 µg/mL for Betadine solution). The alcohol/copolymer control exhibited no bactericidal activity.

Table 3. MBCs for DuraPrep Solution and Betadine Solution

Organism	Type	Range of MBCs After 30-Minute Contact (µg/mL Available Iodine)	
		DuraPrep Solution	Betadine Solution
<i>Burkholderia cepacia</i>	10 ATCC Isolates	8->16	2-16
<i>Enterococcus faecalis</i>	2 ATCC Isolates	4-8	4
	8 Clinical Isolates	8-16	2-8
<i>Escherichia coli</i>	2 ATCC Isolates	8	2-4
	8 Clinical Isolates	4-16	2-8
<i>Staphylococcus epidermidis</i>	7 ATCC Isolates	2-16	1-4
	3 Clinical Isolates	4-8	2-4
<i>Staphylococcus aureus</i> (MSSA)	2 ATCC Isolates	4	2-4
	8 Clinical Isolates	4-8	1-2
<i>Staphylococcus aureus</i> (MRSA)	3 ATCC Isolates	2-4	1-2
	7 Clinical Isolates	2-8	1-4

► *In Vitro* Time-Kill Assay, “Dried Film” Filter Method

Purpose

The purpose of this study (completed in 1997) was to determine the bactericidal activity of iodine released from dried antiseptic films over time against specific bacteria and yeast.

Method

The iodine released from dried iodophor films was assessed by exposing the film to test organisms for 1, 5, and 15 minutes. The test was designed to determine the activity of the povacrylex component in 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation in the absence of isopropyl alcohol and simulate the introduction of transient organisms onto the prep surface (i.e., the surgical field). The number of organisms placed onto the prep represented an excess bacterial load – one that is over and above that expected to be present in an operating room during surgery.

DuraPrep solution, Betadine® Solution (1% available iodine), or an alcohol/copolymer control were applied onto sterile membrane filters and allowed to dry. Aliquots of a diluted bacterial suspension ($\sim 10^7$ total CFUs) were pipetted onto the surface of the dried antiseptic film for contact times of 1, 5, and 15 minutes. Filters were transferred to tubes containing sterile neutralizing buffer, used to stop the activity of the antiseptic, and were processed to suspend the test organisms. Samples were diluted and plated into an appropriate growth medium. Plates were incubated at 35°C for 24–48 hours. Colony forming units (CFUs) were enumerated using standard methods. Log reductions were calculated by subtracting the bacterial recovery of treated filters from those of non-treated filters. Twenty-seven (27) bacterial strains were tested. All test organisms, antiseptics, and contact times were run in duplicate (n=2). The isolates tested and the time-kill data for DuraPrep solution are given in Table 4.

Results

Betadine solution and DuraPrep solution exhibited similar rates of kill against the majority of organisms tested. Betadine solution appeared to have slightly greater kill against *Candidia albicans* and *Enterobacter aerogenes* at 1 and 5 minutes and against *Klebsilla pneumoniae* and *Serratia marcescens* at 1 minute. DuraPrep solution demonstrated slightly higher kill against *E. faecalis* ATCC 51299 (vancomycin-resistant *Enterococcus*) and *Streptococcus pyogenes* at 1 minute. The significance, if any, of these differences has not been determined. The antimicrobial activity of both DuraPrep solution and Betadine solution at the 15-minute time point was similar against all organisms tested.

Table 4

Microorganism	Organisms Placed on Top of Dried DuraPrep Film* % Microbial Kill		
	1 Minute	5 Minute	15 Minute
<i>Acinetobacter baumannii</i> (ATCC 19606)	99.99	99.99	99.99
<i>Acinetobacter lwoffii</i> (ATCC 15309)	99.99	99.96	99.99
<i>Burkholderia cepacia</i> (ATCC 25416)	99.92	99.61	99.99
<i>Enterobacter aerogenes</i> (ATCC 13048)	88.39	95.07	99.99
<i>Enterobacter cloacae</i> (ATCC 13047)	99.99	99.99	99.99
<i>Escherichia coli</i> (ATCC 11229)	99.99	99.99	99.99
<i>Escherichia coli</i> (ATCC 25922)	99.77	99.99	99.99
<i>Haemophilus influenzae</i> (ATCC 19418)	99.99	99.99	99.99
<i>Klebsiella oxytoca</i> (ATCC 43165)	99.97	99.99	99.99
<i>Klebsiella pneumoniae</i> (ATCC 11296)	99.13	99.99	99.99
<i>Proteus mirabilis</i> (ATCC 7002)	99.99	99.99	99.99
<i>Pseudomonas aeruginosa</i> (ATCC 9027)	99.99	99.99	99.99
<i>Serratia marcescens</i> (ATCC 14756)	99.61	99.99	99.99
<i>Corynebacterium jeikeium</i> (ATCC 43734)	99.99	99.99	99.99
<i>Enterococcus faecalis</i> (ATCC 19433)	99.82	99.99	99.99
<i>Enterococcus faecalis</i> (VRE) (ATCC 51299)	99.19	99.99	99.99
<i>Enterococcus faecium</i> (ATCC 19434)	82.12	99.99	99.99
<i>Micrococcus luteus</i> (ATCC 4698)	99.95	99.99	99.99
<i>Staphylococcus aureus</i> (ATCC 6538)	97.72	99.96	99.99
<i>Staphylococcus aureus</i> (MRSA) (ATCC 33592)	84.93	99.60	99.99
<i>Staphylococcus epidermidis</i> (ATCC 12228)	99.99	99.99	99.99
<i>Staphylococcus haemolyticus</i> (ATCC 29970)	99.99	99.99	99.99
<i>Staphylococcus hominis</i> (ATCC 27844)	99.99	99.99	99.99
<i>Staphylococcus saprophyticus</i> (ATCC 15305)	99.61	99.99	99.99
<i>Streptococcus pneumoniae</i> (ATCC 6303)	99.99	99.99	99.99
<i>Streptococcus pyogenes</i> (ATCC 19615)	96.08	99.99	99.99
<i>Candida albicans</i> (ATCC 10231)	80.59	99.06	99.99

MRSA — methicillin-resistant *Staphylococcus aureus*
 VRE — vancomycin-resistant *Enterococcus*

* 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation once it's dry

► *In Vitro* Time-Kill Assay of 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation

Purpose

The objective of the study (completed in 2002) was to determine the *in vitro* rate of microbial kill of 15 organisms by DuraPrep solution after 15 seconds contact time.

Method

Approximately 2×10^8 CFU/filter of each bacterial suspension was applied to the surface of duplicate membrane filters for each contact time. Test material (0.5 mL) was applied to the filters for 15 sec, 30 sec and 1 minute. The activity of the

test material was stopped (neutralized) at each time point. Surviving bacteria were enumerated and the log reduction from the initial population was calculated.

Results

DuraPrep solution demonstrated rapid* bactericidal activity against the broad range of microorganisms, including antibiotic-resistant organisms, as shown in Table 5.

Table 5

Organism	ATCC #	% Kill at 15 sec.	% Kill at 30 sec.	% Kill at 1 min.
<i>Enterococcus faecalis</i>	29212	99.99	99.99	99.99
<i>Enterococcus faecalis</i> (VRE)	51299	99.99	99.95	99.99
<i>Enterococcus faecium</i> (MDR)	51559	99.99	99.99	99.99
<i>Escherichia coli</i>	11229	99.99	99.99	99.99
<i>Escherichia coli</i>	25922	99.99	99.99	99.99
<i>Micrococcus luteus</i>	7468	98.90	99.76	99.99
<i>Pseudomonas aeruginosa</i>	15442	99.99	99.99	99.99
<i>Pseudomonas aeruginosa</i>	27853	99.99	99.99	99.99
<i>Serratia marcescens</i>	14756	99.99	99.99	99.99
<i>Staphylococcus aureus</i>	29213	99.99	99.99	99.99
		99.99	99.99	99.99
<i>Staphylococcus aureus</i>	6538	99.99	99.99	99.99
<i>Staphylococcus aureus</i> (MRSA)	33592	99.99	99.99	99.98
		99.99	99.99	99.99
<i>Staphylococcus epidermidis</i>	12228	99.99	99.99	99.99
<i>Staphylococcus epidermidis</i> (MRSE)	51625	99.99	99.99	99.99
		97.00	99.99	99.99
<i>Candida albicans</i>	10231	99.84	99.99	99.99

MRSA — methicillin-resistant *Staphylococcus aureus*

MDR — multiple drug resistant (ampicillin, ciprofloxacin, gentamicin, rifampin, teicoplanin, vancomycin)

VRE — vancomycin-resistant *Enterococcus*

MRSE — methicillin-resistant *Staphylococcus epidermidis*

* In clinical practice, however, DuraPrep solution is flammable until completely dry (minimum of 3 minutes on hairless skin; up to 1 hour in hair).

► *In Vitro* Bactericidal Efficacy of 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation Compared to Povidone-Iodine

Purpose

In vitro bactericidal efficacy of DuraPrep solution and Betadine® Solution (1% available iodine) was assessed against four pathogens isolated most frequently from surgical wound infections: *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Enterococcus faecalis*. The study was conducted in 1987.

Method

The test was conducted by dispersing the organisms evenly over a membrane filter. DuraPrep solution or Betadine solution was then applied and the filter was incubated at room temperature for 1 and 2 minutes.

Results

E. coli, *S. aureus*, and *P. aeruginosa* were all reduced below detectable levels (>6-log₁₀ reduction) by both antimicrobial agents at both time points. DuraPrep solution was more effective against *E. faecalis* (6-log reduction at both 1 and 2 minutes) than Betadine solution (1-log reduction at 1 minute and 3-log reduction at 2 minutes).

► Determination of Antimicrobial Activity of Iodine Released from 3M DuraPrep Solution and Povidone-Iodine Dried Films

Purpose

The bactericidal activity of DuraPrep solution, povidone-iodine tincture (0.7% available iodine in isopropyl alcohol 74% w/w) and an alcohol/copolymer control was measured and compared in a study conducted in 1995.

Method

Solutions were applied evenly to the surface of a membrane filter and allowed to dry completely. Bacterial suspensions of *E. faecalis*, *P. aeruginosa*, *S. aureus*, *S. epidermidis*, and *E. coli* (all ATCC isolates) were applied to the surface of the dried film (~10⁶–10⁷ CFUs). After contact times of 1, 2 or 5 minutes, filters were processed to suspend the bacteria. Samples were diluted and plated onto appropriate growth medium. Plates were enumerated following incubation at 35° C for 24 to 48 hours. This test method simulates the addition of transient organisms onto the prep surface.

Results

Maximum bacterial reduction was achieved against all strains, with the exception of *E. faecalis*, within one-minute contact time, for both dried DuraPrep solution and dried povidone-iodine tincture. For *E. faecalis*, DuraPrep solution demonstrated a 3-log reduction at two minutes and complete reduction within 5 minutes, compared to the povidone-iodine tincture film, which reduced *E. faecalis* to undetectable levels within one minute. The alcohol/copolymer control did not exhibit antimicrobial activity against any of the test organisms.

► Determination of the Antimicrobial Activity of 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation and Povidone-Iodine Against Antibiotic-Resistant Organisms

Purpose

The efficacy of DuraPrep solution, Betadine® Solution (1% available iodine), Hibiclens® Antiseptic/Antimicrobial Skin Cleanser (4% chlorhexidine gluconate), and Pharmaseal® Povidone Iodine Topical Gel (1.0% available iodine) against clinically important antibiotic-resistant gram-positive bacteria was measured and compared. The study was conducted in 1992.

Method

Bacterial suspensions of antibiotic-resistant clinical isolates of *Staphylococcus aureus*, *Enterococcus faecium*, *Enterococcus faecalis*, and *Staphylococcus epidermidis* were applied to the surface of a membrane filter (~10⁶–10⁷ CFUs— see Table 6). The test antiseptic was applied to the filter and incubated at room temperature for 1, 2, 5 or 10 minutes. Samples were diluted and plated in an appropriate growth medium. Plates were incubated overnight at 35°C and counted using an automated colony counter. An alcohol/copolymer control was also included in the testing. Note that all antiseptics were not tested at all times or with all isolates.

Results

The results are given in Tables 7–10 and summarized below.

Methicillin-resistant *S. aureus*

DuraPrep solution reduced *S. aureus* to undetectable levels after only a one-minute contact time (Table 7). Betadine solution killed methicillin-resistant *S. aureus* more readily than the enterococci with 3-log reductions being achieved in 2 minutes or less for strains 524 and 525 and in 5 minutes for strain 508. When testing Betadine solution again (Table 8) and Hibiclens solution against strain 508, Betadine solution required >2 minutes to achieve a 3-log reduction; while Hibiclens solution achieved a 4-log reduction within 1 minute of contact.

Enterococci

In all but one instance, DuraPrep solution showed

undetectable bacterial levels (<2 logs) within 1 minute on the *Enterococcus* sp. More than 5 minutes were required by Betadine® solution to achieve a 3-log reduction and in the case of strain 512, a 3-log reduction was not achieved even after 10 minutes (Table 7). Betadine solution reduced *E. faecalis* 514 to undetectable levels only after a 10-minute contact time. The povidone-iodine topical gel was tested against *E. faecium* 517. A 3-log reduction was achieved within 2 minutes; however, reduction of bacteria to undetectable levels was not reached even after 10 minutes (Table 9).

Vancomycin-resistant *E. faecium*

A single strain of vancomycin-resistant *E. faecium* was tested against DuraPrep solution, Betadine solution, and Hibiclens solution. Hibiclens solution appeared to be more effective against *E. faecium* 517 than Betadine solution but not as effective as DuraPrep solution (Table 10). This strain was extremely sensitive to DuraPrep solution and was reduced to undetectable levels within 2 minutes.

Control data comparing DuraPrep solution to the alcohol/copolymer indicated that the rapid kill observed with DuraPrep solution is due in large part to the antimicrobial effect of the isopropyl alcohol.

Table 6

Organisms Tested	
Bacterial Strain (Ref #)	Description
<i>S. aureus</i> Bradley (508)	Methicillin-resistant Phase Type Unknown United States
<i>S. aureus</i> MS16266 (524)	Methicillin-resistant Phase Type 29/52/71/83A/95/96 Japan
<i>S. aureus</i> MS16298 (525)	Methicillin-resistant Phase Type 83A/84/85 Japan
<i>S. epidermidis</i> BK1071 (516)	Methicillin-resistant United States
<i>E. faecium</i> #2491 (517)	Vancomycin-resistant United States
<i>E. faecalis</i> BE83 (514)	High-level Gentamicin Resistance Thailand
<i>E. faecalis</i> CE30 (512)	High-level Gentamicin Resistance Chile

Table 7

Contact Time	1 Minute		2 Minute		5 Minute		10 Minute	
	DuraPrep Solution*	Betadine Solution	DuraPrep Solution	Betadine Solution	DuraPrep Solution	Betadine Solution	DuraPrep Solution	Betadine Solution
<i>S. aureus</i> Bradley (508)	6.67	.095	6.75	1.86	6.75	6.60	—	—
<i>S. aureus</i> MS16266 (524)	6.86	3.62	6.86	6.86	—	—	—	—
<i>S. aureus</i> MS16298 (525)	6.76	2.21	6.76	3.95	—	—	—	—
<i>S. epidermidis</i> BK1071 (516)	6.38	6.38	6.38	6.38	—	—	—	—
<i>E. faecium</i> #2491 (517)	6.17	0.92	6.77	1.16	6.77	3.01	6.77	5.86
<i>E. faecalis</i> BE83 (514)	6.83	0.69	6.83	1.51	6.83	3.34	6.83	6.83
<i>E. faecalis</i> CE30 (512)	6.74	.039	6.74	1.02	6.74	1.05	6.74	2.17

Table 8

Contact Time	1 Minute		2 Minute	
	Betadine Solution	Hibiclens Cleanser	Betadine Solution	Hibiclens Cleanser
<i>S. aureus</i> Bradley (508)	1.81	4.31	2.27	6.85

Table 9

Contact Time	1 Minute		2 Minute		5 Minute		10 Minute	
	DuraPrep Solution	Pharmaseal Gel	DuraPrep Solution	Pharmaseal Gel	DuraPrep Solution	Pharmaseal Gel	DuraPrep Solution	Pharmaseal Gel
<i>E. faecium</i> #2491 (517)	6.74	2.39	6.74	2.91	6.74	5.08	6.74	5.44

Table 10

Contact Time	1 Minute			2 Minute			5 Minute			10 Minute		
	DuraPrep Solution	Hibiclens Cleanser	Betadine Solution	DuraPrep Solution	Hibiclens Cleanser	Betadine Solution	DuraPrep Solution	Hibiclens Cleanser	Betadine Solution	DuraPrep Solution	Hibiclens Cleanser	Betadine Solution
<i>E. faecium</i> #2491 (517)	6.17	2.68	0.92	6.77	3.15	1.16	6.77	—	3.01	6.77	—	5.89

* 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation

► *In Vitro* Studies on the Mechanism and Extent of Release of Iodine from Various Iodophors

Background

While iodine is the active ingredient in the three products studied, 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation, Betadine® Solution (1% available iodine) and Pharmaseal® Povidone-Iodine Topical Gel (1% available iodine), the rate of iodine release is controlled by the formulation and influenced by the environment.

Since DuraPrep solution forms a water-insoluble film in contrast to the water-soluble products, the release rate of iodine between these products was compared. Testing was done in 1996 at the University of Kentucky School of Pharmacy in a 3M-funded study.

Method

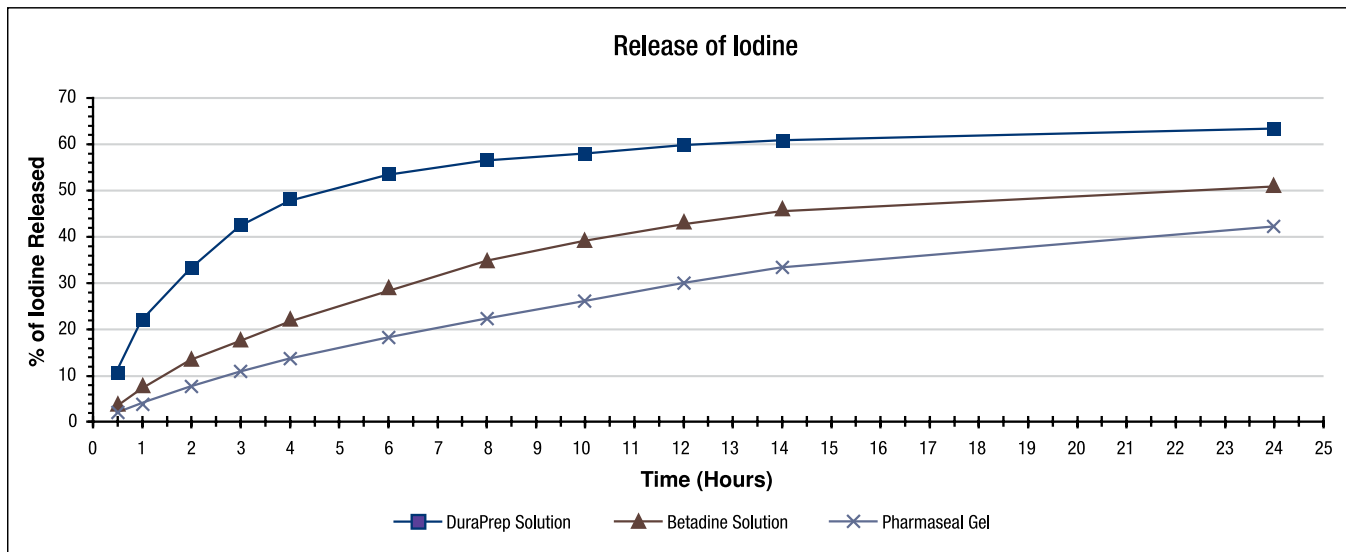
The *in vitro* method used to compare iodine release rates is the Franz Cell method. Pharmaceutical companies utilize this method for comparison of the release rate of drugs. Iodine release was measured by radiolabeling the iodine in each product, then monitoring the release by measuring the change in radioactivity over time. To simulate surgical conditions, the experiments were conducted at 37°C. Radiolabeled products were placed on a synthetic membrane that was held in a chamber over lactated Ringers solution.

At various time intervals, up to 24 hours, the solution in the chamber below the membrane was removed and the amount of iodine that had been released from the complex and crossed the membrane was quantified. Radiolabeling the iodine allowed quantification by measuring the radioactivity of the solution. Each product was directly compared in duplicate or triplicate and the experiment was replicated four times to obtain sufficient data for statistical comparison.

Results

The results are shown in Figure 1 below. All products released iodine. However, the rates of release were statistically different. DuraPrep solution released iodine at a rate faster than Betadine solution and the Pharmaseal gel, which had the slowest release.

Figure 1



► Recovery of Organisms from Skin Prepped with 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation

Purpose

The primary objective of this study was to test the ability of a modified skin sampling solution to dissolve the DuraPrep copolymer film (after being dried on skin) and allow the recovery of organisms from beneath the antiseptic film. The study was conducted in 1997.

Method

To test the modified skin sampling solution, bacterial spores were seeded onto human skin prior to the application of DuraPrep solution. Five subjects were enrolled and all subjects received all treatments. Nonpathogenic bacterial spores were evenly distributed over five sites on each volar forearm after alcohol-prepping the skin. DuraPrep solution, Betadine® Solution (1% available iodine), isopropyl alcohol 74% (w/w), or sterile saline (untreated recovery control) was applied to the surface of the seeded sites. After test sites were dry, spores were recovered using a Modified Sampling Solution (MSS) or a Standard Sampling Solution (SSS). The recovery of spores was quantified using standard methods.

Results

The means and standard deviations of spore recovery after the various treatments are shown in Table 11. Recovery of spores from under the DuraPrep film was very similar to recovery of spores from IPA-treated sites and from the untreated control sites sampled with the MSS, indicating that the DuraPrep film was adequately dissolved allowing for the recovery of spores.

Table 11. Means and Standard Deviations of Spore Recovery

Treatment	N	Mean Log Count	STD
Betadine Solution (MSS)	5	5.85	0.15
DuraPrep Solution (MSS)	5	5.58	0.28
Isopropyl Alcohol (MSS)	5	5.62	0.22
Untreated (MSS)	5	5.58	0.29
Untreated (SSS)	5	5.92	0.23

► Antimicrobial Effectiveness of 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation Against Resident Human Skin Flora on Abdomen and Groin Sites

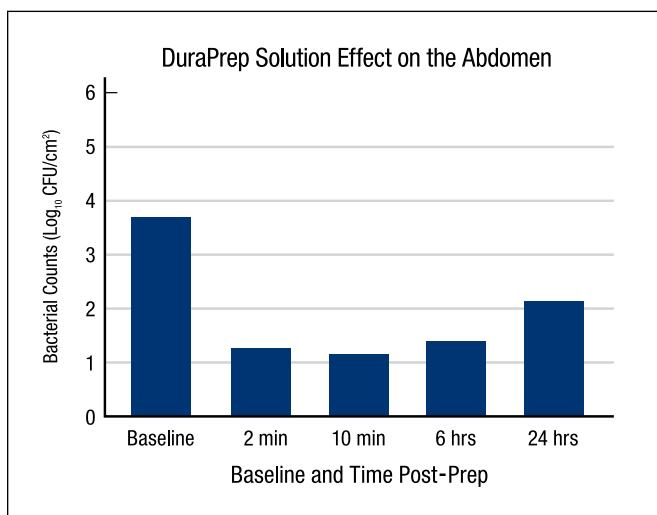
Purpose

The primary objective was to assess the bactericidal effect of DuraPrep solution on the abdomen and groin. The studies were conducted in 2002 using the methodology described in the 1994 Tentative Final Monograph for Health-Care Antiseptic Drug Products (TFM).

Method

Sixty-six subjects who met the minimum screening requirement of $5 \log_{10}$ CFU/cm² per groin site were enrolled and randomized. One hundred and six subjects who met the minimum screening requirement of $3 \log_{10}$ CFU/cm² per abdomen site were enrolled and randomized. On test day, baseline samples were collected, the respective test solutions applied to each test area, and microbial samples collected at 10 minutes, 6 hours, and 24 hours post-prep for the groin; 2 minutes*, 10 minutes, 6 hours, and 24 hours post-prep for the abdomen. Samples were collected with a solution that was verified to neutralize the active ingredients in the preps. This test protocol has no fluid challenge.

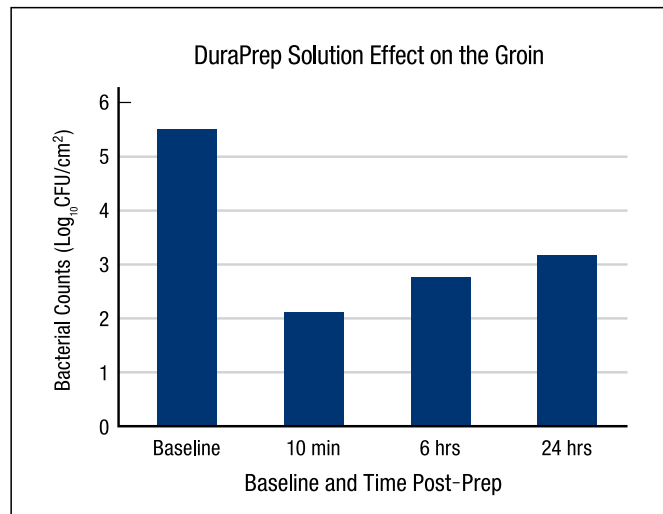
Figure 2



Results

The average log recovery is shown for the abdomen and groin in Figures 2 and 3. DuraPrep solution met the TFM criteria for bacterial reduction ($2 \log_{10}$ CFU/cm² on the abdomen and $3 \log_{10}$ CFU/cm² on the groin) and kept bacterial counts below baseline for at least 24 hours.

Figure 3



► DuraPrep Solution — Efficacy and Color after a Blood/Saline Wash

Purpose

The purpose of this study (conducted in 2002) was to compare the durability and persistence of antimicrobial activity of DuraPrep film (DuraPrep solution once it is dry) and Betadine® Scrub and Betadine® Solution (hereafter referred to as Betadine combination) following a wash with autologous blood and saline. Treated areas were challenged with a tetracycline-resistant strain of *Staphylococcus aureus* (ATCC 27217), which was applied to the surface of the test site at 2 time points following the treatment. The results of this study were intended to demonstrate that DuraPrep film is insoluble in water, resists wash-off, and has antimicrobial activity on top of the film for up to 6 hours following treatment.

*In clinical practice, however, DuraPrep solution is flammable until completely dry (minimum of 3 minutes on hairless skin: up to 1 hour in hair).

Method

After a single application of 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation, the dried film (at 15 minutes post-prep) was exposed to autologous blood for 2 minutes, the blood was removed with saline-soaked gauze and the site dried. A known quantity of *S. aureus* (approximately 10⁶ CFUs) was placed on top of the dry film at 15 minutes and 6 hours post-prep, allowed to remain *in situ* for 5 or 30 minutes, and recovered using a modified scrub cup technique. Samples were collected with a solution that was verified to neutralize the active ingredients in the preps. Enumeration of bacterial counts was performed by individuals who were blinded to the identities of the test product associated with each sample. In addition, the color of each prep was evaluated before and after the blood and saline wash and at 6 hours.

Results

Figure 4 shows the log reduction of DuraPrep solution at the 6-hour post-prep, 30-minute bacterial residence time (the primary analysis point). This was significantly greater than that of Betadine® combination ($P = .0098$, Betadine data not shown). At the other time points, the differences were not statistically significant. The durability of the film and the antimicrobial persistence was maintained for at least 6 hours after exposure to blood and saline.

Figure 5 shows the level of color retention seen after the blood and saline wash. After the blood and saline wash and at 6 hours post-prep, the color on 100% of the DuraPrep solution-treated sites remained clearly visible; the color of the Betadine combination-treated sites was less evident. The difference in the color of the DuraPrep solution and the Betadine combination treated sites was statistically significant. DuraPrep film resisted removal after the blood and saline wash and at 6-hours post-prep.

DuraPrep film is insoluble in water and resists wash-off, as demonstrated by the retention of both antimicrobial activity and color intensity following a wash with autologous blood and saline.

Figure 4

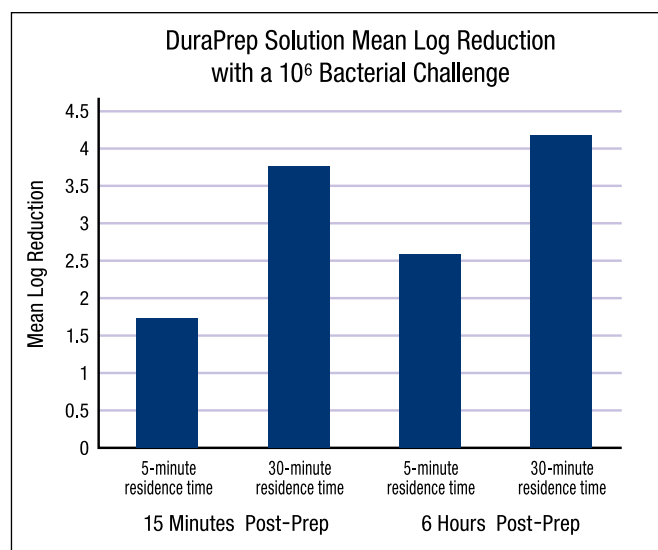
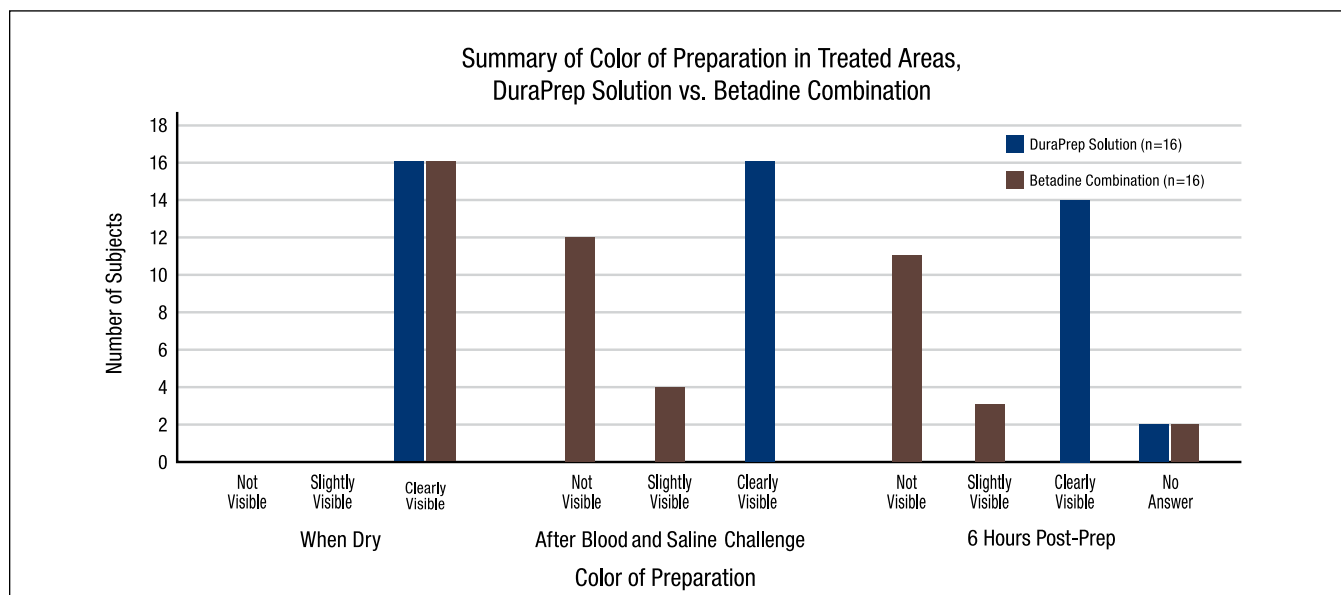


Figure 5



► Antimicrobial Persistence of 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) After 48 hours Following Exposure to Blood and Saline

Purpose

The purpose of this study (conducted in 2007) was to evaluate the durability and antimicrobial effectiveness of DuraPrep solution following a blood and saline challenge by measuring the regrowth of normal skin flora beneath a 3M™ Tegaderm™ Transparent Adhesive Dressing (TAD) on the human back at 48 hours post-prep.

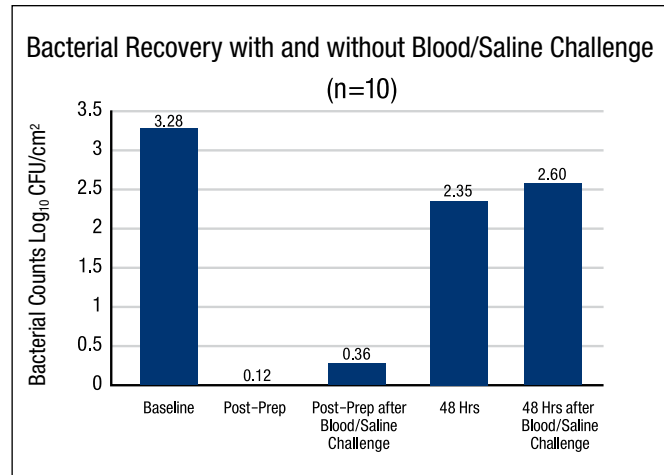
Method

Baseline bacterial counts were taken on the backs of ten healthy volunteers. DuraPrep solution was applied and allowed to dry. Post-prep counts were taken 10 minutes after the prep dried. Half of the remaining prepped area was then challenged with 3 mL of the subject's blood pipetted onto sterile gauze. The blood-soaked gauze remained in place for 5 minutes. Then a fresh piece of sterile gauze was placed onto the test site and 2.5 mL of sterile saline was pipetted onto it. The saline-soaked gauze remained in place for a period of 20 minutes. After the blood/saline challenge, post-prep sampling was again performed. Samples were collected with a solution that was verified to neutralize the active ingredients in the preps. The remaining sites were covered with a sterile Tegaderm film without adhesive. This non-adherent covering was then further protected with a Tegaderm dressing for 48 hours. After 48 hours, the coverings were removed and the test sites were sampled.

Results

DuraPrep solution suppresses regrowth of bacteria for at least 48 hours* with and without a blood and saline challenge (to simulate surgical conditions). (Figure 6).

Figure 6



*Following ASTM E1173

► The Resistance of Preoperative Skin Preparations to Saline Rinse

Stahl JB, Morse D, Parks PJ. Resistance of antimicrobial skin preparations to saline rinse using a seeded bacteria model. *Am J Infect Control.* 2007;35(6):367-373.

Purpose

Evaluate the antimicrobial persistence following saline exposure of two commercially-available skin antiseptic agents.

Method

This prospective, randomized study was conducted on 36 healthy subjects using 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) and ChloraPrep® Patient Preoperative Skin Preparation 2% Chlorhexidine Gluconate (CHG) & 70% Isopropyl Alcohol (IPA). Both agents were applied to the forearms of subjects according to manufacturers’ instructions and allowed to dry. The sites were then exposed to either a saline rinse or to a saline-saturated gauze (sponge), similar to the challenges that preps would face during most surgical procedures. Two analyses were performed: 1) An indicator organism was seeded onto the treated sites. After 30 minutes, samples were collected from the treated sites and surviving bacteria were counted and log reductions calculated. Samples were collected with a solution that was verified to neutralize the active ingredients in the preps. 2) The saline-saturated gauze was analyzed chemically for presence of chlorhexidine or iodine.

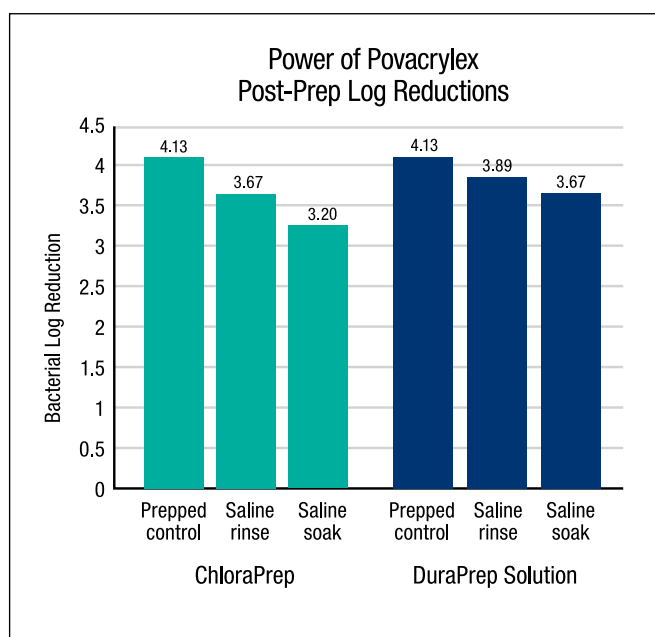
Study

The baseline bacterial counts of the sites had statistically equivalent microbial levels prior to the additional seeding of test microbes. Both agents reduced the microbial level with statistical significance although the iodine povacrylex/alcohol solution had significantly higher log reductions of seeded organisms compared with the chlorhexidine/alcohol solution for the saline-soak condition ($P=.006$). (Figure 7). Chemical analysis of the evaluated gauze samples indicated that 100% of samples evaluated from subjects prepped with ChloraPrep contained detectable chlorhexidine levels, while none of the gauze samples evaluated from subjects prepped with DuraPrep solution contained detectable levels of iodine. ($P<.0001$).

Conclusions

Iodine povacrylex/alcohol solution had significantly higher log reductions of seeded organisms compared with chlorhexidine/alcohol solution for the saline-soak condition ($P=.006$). The chemical testing results demonstrated that the iodine in the iodine povacrylex was more resistant to removal by saline-soaked gauze than the chlorhexidine/alcohol solution ($P < .0001$). The implication is that similar results may occur in surgery when saline is used.

Figure 7



► Antimicrobial Drape Adhesion to 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation and ChloraPrep® Patient Preoperative Skin Preparation 2% Chlorhexidine Gluconate (CHG) & 70% Isopropyl Alcohol (IPA)

Purpose

The purpose of this study was to compare the drape adhesion of 3M™ Ioban™ 2 Antimicrobial Incise Drapes to skin prepped with DuraPrep solution and ChloraPrep under simulated (wet) surgical conditions.

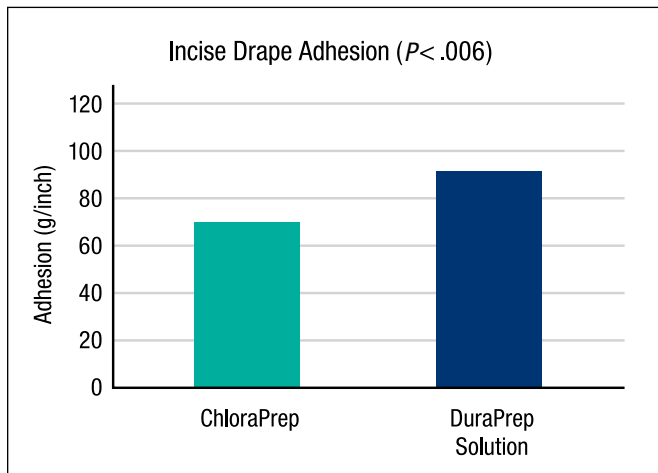
Method

After the preps were applied and allowed to dry on the backs of 16 healthy volunteers, drape samples were placed on top of the preps using a 4.5-lb. roller. The drape samples were allowed to build adhesion for 5 minutes. After the 5-minute adhesion build, 0.9% saline-soaked gauze was applied to the drape samples for 30 minutes, with additional saline solution re-applied to the gauze every 10 minutes to simulate “wet” surgical conditions. The gauze was removed and the drape samples were pulled off under controlled conditions using an instrument designed to measure adhesion and peel.

Results

There was a significant effect of the prep on drape adhesion ($P < .006$). DuraPrep solution provided significantly better drape adhesion than ChloraPrep (Figure 8).

Figure 8



► Antimicrobial Drape Adhesion to DuraPrep Solution and Prevail-Fx® Antimicrobial Solution

Purpose

The purpose of this study was to compare the drape adhesion of Ioban 2 Antimicrobial Incise Drapes to skin prepped with DuraPrep solution and Prevail-Fx Antimicrobial Solution under simulated (wet) surgical conditions.

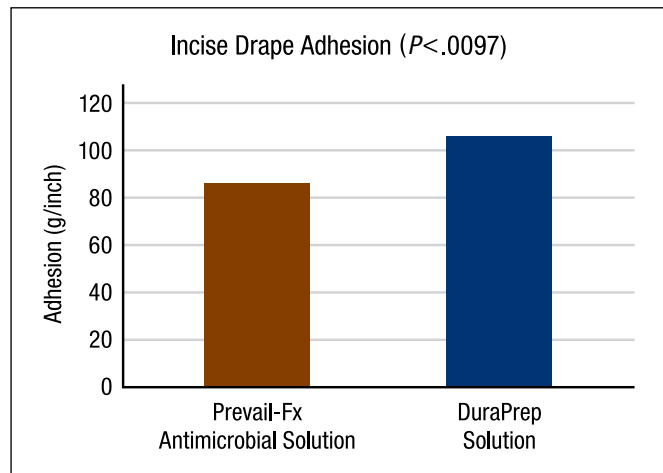
Method

After the preps were applied and allowed to dry on the backs of 32 healthy volunteers, drape samples were placed on top of the preps using a 4.5-lb. roller. The drape samples were allowed to build adhesion for 5 minutes. After the 5-minute adhesion build, 0.9% saline-soaked gauze was applied to the drape samples for 30 minutes, with additional saline solution re-applied to the gauze every 10 minutes to simulate “wet” surgical conditions. The gauze was removed and the drape samples were pulled off under controlled conditions using an instrument designed to measure adhesion and peel.

Results

There was a significant effect of the prep on drape adhesion ($P < .0097$). DuraPrep solution provided significantly better drape adhesion than Prevail-Fx Antimicrobial Solution. (Figure 9).

Figure 9



► **Antimicrobial Drape Adhesion to 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation, Betadine® Combination, and Hibiclens® Antiseptic/Antimicrobial Skin Cleanser (4% chlorhexidine gluconate)**

Purpose

The purpose of this study was to compare the drape adhesion of 3M™ Ioban™ 2 Antimicrobial Incise Drape to skin prepped with DuraPrep solution, Betadine combination, and Hibiclens cleanser under simulated (wet) surgical conditions.

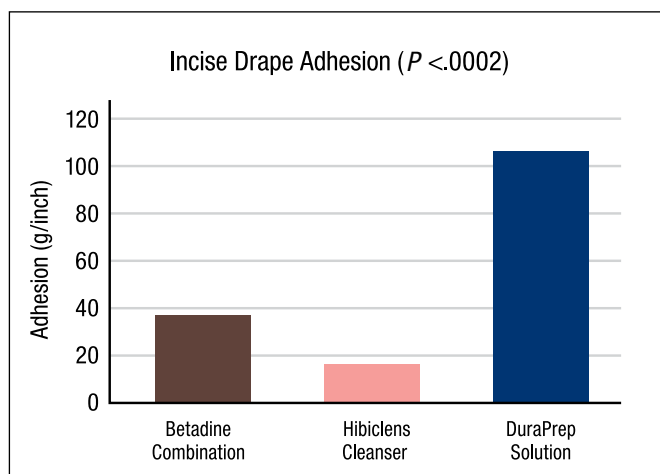
Method

After the preps were applied and allowed to dry on the backs of 12 healthy volunteers, drape samples were placed on top of the preps using a 4.5-lb. roller. The drape samples were allowed to build adhesion for 5 minutes. After the 5-minute adhesion build, 0.9% saline-soaked gauze was applied to the drape samples for 20 minutes to simulate “wet” surgical conditions. The gauze was removed and the drape samples were pulled off under controlled conditions using an instrument designed to measure adhesion and peel.

Results

There was a significant effect of the prep on drape adhesion ($P < .0002$). DuraPrep solution provided significantly better drape adhesion than Betadine combination and Hibiclens cleanser. (Figure 10).

Figure 10



► **Preoperative Surgical Skin Preparation of Cardiac Patients**

Refer to the following published article for complete study details: Segal CG, Anderson JJ. Preoperative skin preparation of cardiac patients. *AORN Journal*. 2002;76(5):821-828.

Purpose

Eight cardiovascular surgeons used different prepping regimens at the hospital and embarked on a study to see if standardizing on one prepping method would reduce postoperative sternal surgical site infections (SSIs) associated with coronary artery bypass graft (CABG) procedures in patients who were at high risk.

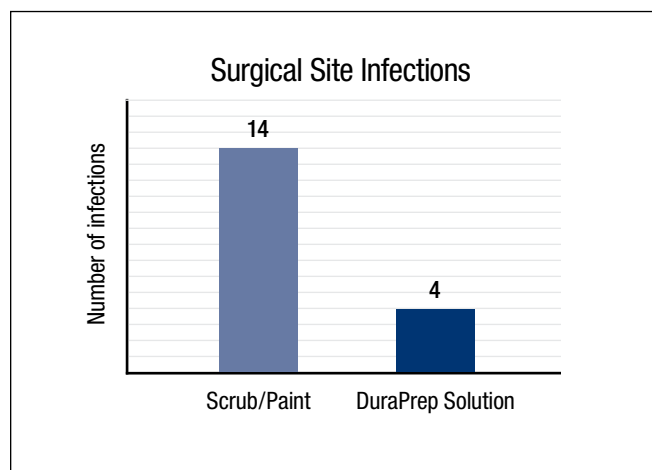
Method

Patients with one or more high-risk predictive factors were randomly enrolled into one of four treatment groups: those receiving povidone-iodine paint (group 1), povidone-iodine five-minute scrub and paint (group 2), one-step iodophor/alcohol water-insoluble prep (3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation, group 3), and one-step iodophor/alcohol water-insoluble prep with iodine impregnated incise drape (group 4).

Results

Patients who were prepped with DuraPrep solution (in groups 3 and 4) had fewer infections (4/101) than those prepped with varied povidone-iodine regimens (14/108). (Figure 11).

Figure 11



► Effects of preoperative skin preparation on postoperative wound infection rates

Refer to the published article for complete study details: Swenson BR, Hedrick TL, Metzger R, Bonatti H, Pruett TL, Sawyer RG. Effects of preoperative skin preparation on postoperative wound infection rates: a prospective study of 3 skin preparation protocols. *Infect Control Hosp Epidemiol* 2009; 30:964-971.

Purpose

Surgical site infections (SSI) represent a major source of morbidity and mortality in surgical patients. Infection of the surgical wound can prolong hospitalization, increase the rate of intensive care unit admission, and significantly increase the cost of treatment. Integral to the prevention of surgical site infection is the adherence to aseptic techniques, one of which is the preoperative preparation of the operative site. The purpose of this study was to determine if standardizing preoperative skin preparation modality would have a significant effect on SSI rates on the basis of skin preparation used.

Method

This prospective study evaluated 3,209 general surgery patients over an 18-month period. Three skin preparation solutions were compared. Each skin preparation solution was adopted as the preferred modality for a 6-month period for all included patients.

Povidone-Iodine with Alcohol Paint (Betadine® combination with isopropyl alcohol paint)

The prep was applied with foam sponges or sterile gauze for three consecutive applications of povidone-iodine soap in concentric circles, starting at the incision and moving outward. The surgical site was washed with a single application of 70% isopropyl alcohol in the same manner and a sterile towel was placed over the surgical site and patted dry. The process was then completed with three consecutive applications of 10% povidone-iodine paint.

2% Chlorhexidine and 70% Isopropyl Alcohol (ChloroPrep® Patient Preoperative Skin Preparation 2% Chlorhexidine Gluconate [CHG] & 70% Isopropyl Alcohol [IPA])

The applicator was used to scrub the incision site in a back-and-forth manner for 30 seconds on a dry site and 2 minutes in moist areas.

Iodine Povacrylex (0.7% available iodine) in 74% Isopropyl Alcohol (3M™ DuraPrep™ Surgical Solution [Iodine Povacrylex (0.7% available iodine) and Isopropyl Alcohol, 74% w/w])

The applicator was used to paint the abdomen starting at the incision site in a single uniform application.

Centers for Disease Control defined surgical site infections were tracked for 30 days as part of ongoing data collection for the National Surgical Quality Improvement Project initiative (NSQIP). The primary outcome was the overall rate of SSI by 6-month period performed in an intent-to-treat manner.

Results

The lowest infection rate was seen in period 3 with iodine povacrylex in isopropyl alcohol as the preferred preparation method (3.9%, compared to 6.4% and 7.1% for periods 1 and 2, respectively, $P = .002$). (see Figure 12) In analysis of SSI rate by prep received, no difference was seen between patients prepared with povidone-iodine scrub/paint or iodine povacrylex in isopropyl alcohol, but these had significantly lower SSI rates compared to the use of 2% chlorhexidine and 70% isopropyl alcohol (4.8% vs. 8.2%, $P = .001$). (see Figure 13)

Figure 12

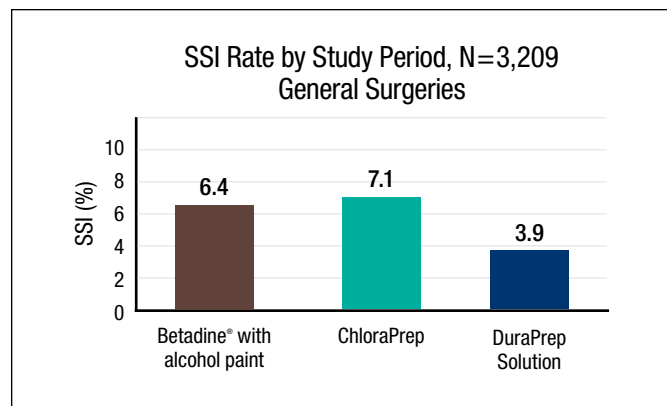
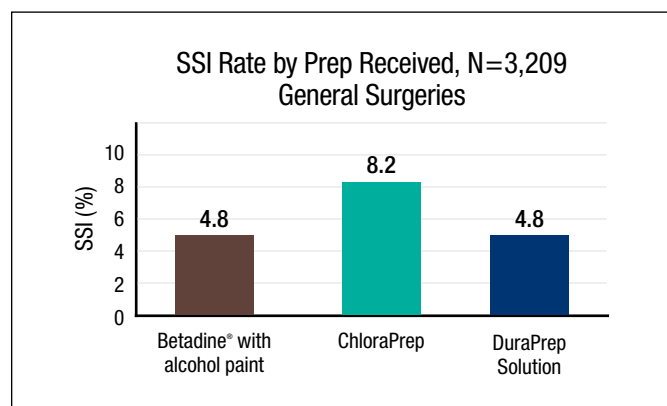


Figure 13



► Effects of Iodophor Skin Preparation in Reducing Surgical Site Infection

Refer to the following published abstract for complete study details: Pinheiro SMC, Couto BRG, Pimenta JPM, Moreira LS, Nogueira MGS, Moreira MNR, Nascimento ES. *Effects of iodophor skin preparation in reducing surgical site infection*. Paper presented at: 14th Annual Meeting of the Society for Healthcare Epidemiology of America; April 2004; Philadelphia, PA.

Purpose

The purpose of the study was to compare 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation to a 1% iodine/alcohol in reducing SSIs associated with general surgery.

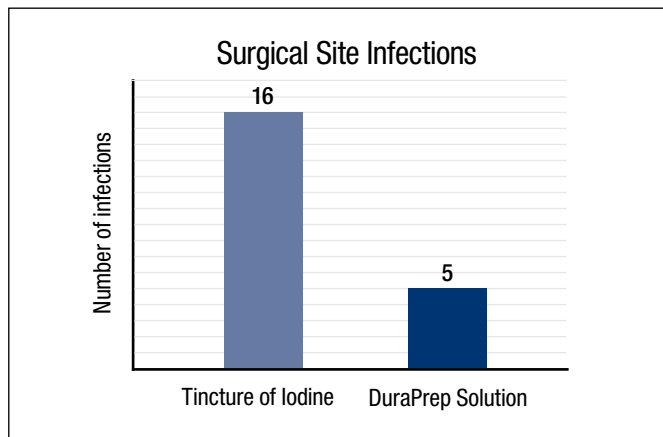
Method

Patients were randomly assigned to receive either DuraPrep solution or 1% iodine/alcohol prior to surgery and followed by infection control personnel during their hospital stay. Infections were classified according to National Nosocomial Infections Surveillance (NNIS) criteria.

Results

In operations taking longer than 3 hours, there was a significantly lower incidence of SSI with DuraPrep solution (5/105) versus 1% iodine/alcohol (16/109). The authors recommend DuraPrep solution for surgeries over 3 hours (Figure 14).

Figure 14



► Prevention of Wound Contamination Using DuraPrep Solution Plus 3M™ Ioban™ 2 Antimicrobial Incise Drapes

Refer to the following published article for complete study details: Jacobson C, Osmon DR, Hanssen A, Trousdale RT, Pagnano MW, Pyrek J, Berbari E, Naessens J. Prevention of wound contamination using DuraPrep™ solution plus Ioban™ 2 drapes. *Clin Orthop Relat Res*. 2005;439:32-37.

Purpose

The purpose of this study was to determine if the use of DuraPrep solution plus Ioban 2 antimicrobial film incise drapes would reduce wound contamination and drape lift in total joint replacement surgery compared to povidone-iodine scrub and paint plus Ioban 2 drapes.

Method

Patients undergoing either a total knee arthroplasty or a total hip arthroplasty were randomly assigned to one of two study groups before the surgical procedure: either the group receiving DuraPrep solution plus Ioban drapes, or the group receiving the povidone-iodine skin prep tray (by Allegiance) plus Ioban drapes. (86 in the DuraPrep solution group and 90 in the PVP-I group)

Results

The DuraPrep solution group had fewer patients with wound contamination, although the frequency of contamination was not statistically different between the study groups. Drape edge lift and total area of drape lift were significantly less in the DuraPrep solution group than in the PVP-I group ($P < .0001$). The length of drape lift was also higher in patients with contaminated wounds. (Table 12). DuraPrep solution group required less prepping time, resulting in reduced operating room costs. In this facility, the use of DuraPrep solution generated a potential savings of \$157 per patient.

Table 12

Variable	DuraPrep Solution (N = 81)	PVP-I (N = 90)	Significance
Total area of drape lift (cm ²)	1.5 ± 2.85	9.9 ± 16.22	$P < .0001$
Edge lift of drape (cm)	2.5 ± 4.22	6.9 ± 7.03	$P < .0001$
Incision length	19.5 ± 3.86	19.2 ± 2.90	Not significant

► Comparison of the Efficacy of Skin Antisepsis for Epidural Catheter Insertions

Refer to the published article for complete study details: Birnbach DJ, Meadows W, Stein DJ, Murray O, Thys DM, Sordillo EM. Comparison of povidone iodine and DuraPrep, an iodophor-in-isopropyl alcohol solution, for skin disinfection prior to epidural insertion in parturients. *Anesthesiology* 2003;98(1):164-169.

Purpose

The purpose of this study was to evaluate the antisepsis achieved with 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation compared with aqueous povidone-iodine (PVP-I) by collecting skin cultures before, during, and at the end of epidural procedures.

Method

Sixty women in active labor who requested epidural analgesia were randomly assigned to receive skin preparation with either PVP-I or DuraPrep solution. A total of three cultures were obtained from each subject. The first was obtained just prior to skin disinfection, the second was obtained immediately following antisepsis, and the third was obtained just before removal of the catheter. In addition, the distal tip of the catheter was also submitted for culture.

Results

The proportion of subjects with positive skin cultures immediately after skin disinfection differed significantly between the PVP-I and DuraPrep solution groups (30% vs. 3%, respectively, $P=.01$). The number of subjects with positive skin cultures at the time of catheter removal was greater in the PVP-I group as compared to the DuraPrep solution group (97% vs. 50%, respectively, $P=.0001$), as was the number of organisms cultured from skin (\log_{10} CFU 1.93 ± 0.40 vs. 0.90 ± 0.23 , respectively, $P=.03$). The number of catheters from the PVP-I group that tested positive were significantly higher than the positives from the DuraPrep solution group (13 vs. 2, respectively, $P=.002$).

Conclusion

As compared to PVP-I, DuraPrep solution was found to provide a greater decrease in the number of positive skin cultures immediately after disinfection, as well as in bacterial regrowth and colonization of the epidural catheters. (Table 13).

Table 13

Positive Cultures	DuraPrep Solution n=30 (%)	PVP-I n=30 (%)	Significance
Skin before disinfection	27 (90)	27 (90)	Not significant
Skin after disinfection	1 (3)	9 (30)	$P=.01$
Skin at catheter removal	15 (50)	29 (97)	$P=.0001$
Catheter tip	2 (7)	13 (43)	$P=.002$

► 3M™ Skin Preparations in CABG Surgery: A Prospective Randomized Trial

Refer to the following published article for complete study details: Roberts AJ, Wilcox K, Devineni R, Harris RB, Osevala MA. Skin preparations in CABG surgery: a prospective randomized trial. *Comp Surg.* 1995;14(6):724, 741-744, 747.

Purpose

The purpose of this study was to compare the efficacy of DuraPrep solution with an aqueous iodophor in cardiac surgery. The key measures were the incidence of wound infection, prep time, incise drape adhesion, and visibility of the skin prep.

Method

Coronary artery bypass patients (200) were randomly assigned to one of two preoperative skin prep groups. The time required to prep the skin was recorded and evaluations of the incise drape adhesion to the chest site and the skin prep visibility on the leg site were made at the end of the procedure. The incidence of postoperative wound infections was also tabulated.

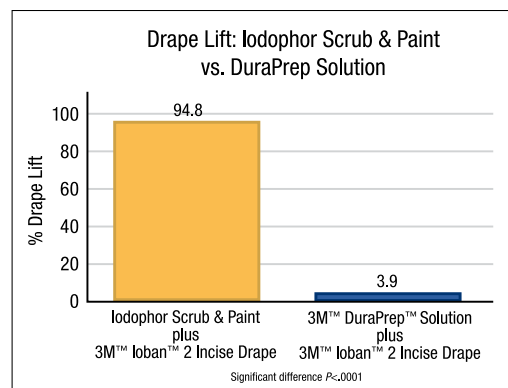
Results

There were no differences in postoperative wound infection rates between the two groups (9.5% wound infection rate overall). The skin prepping time was significantly less with DuraPrep solution ($P<.0001$). Post-operatively, drape adhesion was significantly better with DuraPrep solution ($P<.0001$) as was the retention of the prep on the subject's leg as evidenced by the presence of color ($P<.0001$). A reduction in time also occurred with the DuraPrep solution group. In this facility, the use of DuraPrep solution was associated with a potential savings of \$78 per patient. (Table 14 and Figure 15).

Table 14

	DuraPrep Solution Group n=104	Control Group Traditional 5–10 minute iodophor scrub and paint n=96	Significance
Total number of chest infections	4/104 (3.8%)	6/96 (6.3%)	Not significant
Percent of legs with prep visible on incision site post-surgery	98.1% (102/104)	6.3% (6/96)	P=.0001
Skin preparation time	8 min	19 min	P=.0001
Total Cost at \$7.12/minute	\$56.96	\$135.28	P=.0001

Figure 15



► Cardiac Bypass Surgery: Intervention to Decrease Surgical Site Infections

Refer to the following published abstract for complete study details: Squier C, Miller T, DiLucia B, Bechtold C, Hardesty R, Muder RR. *Cardiac bypass surgery: intervention to decrease surgical site infections*. Paper presented at: 4th Decennial International Conference on Nosocomial and Healthcare-Associated Infections; March 2000; Atlanta, GA.

Purpose

From July 1997 – June 1998, the hospital had 7/152 (4.6%) superficial sternal wound infections and 4/152 (2.6%) deep sternal infections requiring 19 surgical interventions for 4 patients and 372 extra days of hospitalization. The purpose of this study was to decrease SSIs following cardiac bypass surgery. (Table 15).

Method

After standards of practice were evaluated, 3 major changes were implemented. 1) A physician’s assistant (not participating in the graft procedure) was hired solely to harvest saphenous veins, 2) 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation was used as the intraoperative prep, and 3) Pre- and post-operative wound care standards were developed and implemented.

Results

“The implemented changes resulted in a greater than 50% reduction in overall SSI, sternal infection and surgical intervention post-infection. We estimate a reduction of ICU bed days and 15 operative procedures in one year...”

Table 15

	Baseline July 1997–June 1998 (n=152)	Practice Changes Implemented July 1998–June 1999 (n=168)
Total SSI	14 (9.2%)	7 (4.2%)
Superficial sternal infections	7 (4.6%)	0
Deep sternal infections	4 (2.6%)	3 (1.8%)
Surgical interventions needed for infections	19	7

► Comparison of the Efficacy of Skin Antisepsis for Foot and Ankle Surgery

Refer to the published article for complete study details: Ostrander RV, Botte MJ, Brage ME. Efficacy of surgical preparation solutions in foot and ankle surgery. *J Bone Joint Surg Am.* 2005;87(5):980-985.

Purpose

Previous studies have demonstrated higher infection rates following orthopaedic procedures on the foot and ankle compared with procedures involving other areas of the body possibly due to difficulty in removing bacteria from these areas. The purpose of this study was to evaluate the efficacy of 3 different surgical skin-preparation solutions in eliminating potential bacterial pathogens from the foot.

Method

This prospective study evaluated 125 consecutive foot and ankle surgical patients. Each area was prepared with one of 3 randomly selected solutions: 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation, Techni-Care (3.0% chloroxylenol), or ChloroPrep® Patient Preoperative Skin Preparation 2% Chlorhexidine Gluconate (CHG) & 70% Isopropyl Alcohol (IPA). Quantitative culture specimens were obtained from three locations after the preparation and drapping: hallux; web spaces between second and third, and between the fourth and fifth digits (toe sites); anterior tibia (control site).

Results

In the Techni-Care group, bacteria were cultured from 95% of the specimens from hallux sites, 98% of the toe sites, and 35% of the control sites. In the DuraPrep solution group, bacteria were cultured from 65% of the hallux sites, 45% of the toe sites, and 23% of the control sites. In the ChloroPrep group, bacteria were cultured from 30% of the hallux sites, 23% of the toe sites, and 10% of the control sites. ChloroPrep was the most effective agent for eliminating bacteria from the halluces and toes ($P < .0001$). Postoperative infections developed in 3 patients, 2 from the Techni-Care group and 1 from the ChloroPrep group. There were no infections in the DuraPrep solution group. (Figure 16)

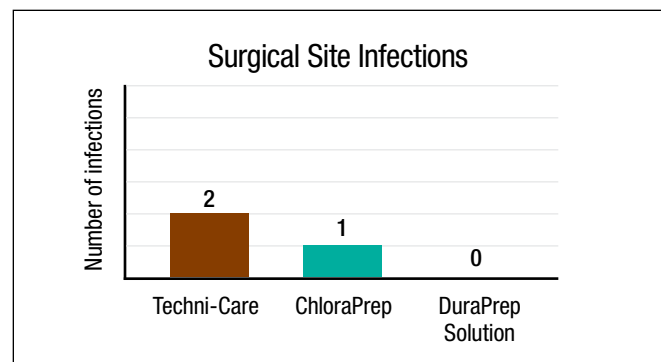
3M Letter to the Editor

Rittle KH. Efficacy of surgical preparation solutions in foot and ankle surgery. *J Bone Joint Surg Am.* 2006;88(5):1160-1161.

In this study, no neutralizer was used in the sampling method even though neutralizing is recommended in ASTM Method E1054-02. A neutralizer inactivates the antimicrobials at the time they are sampled. Without a neutralizer present, the non-film-forming preps (ChloroPrep and Techni-Care) would have continued kill after sampling and consequently inflated kill numbers. Since DuraPrep solution forms a water-insoluble film, the sampling method used would not have been capable of sampling the skin below the film. Therefore, the bacterial counts reported were not sampled from the skin prepped with DuraPrep solution.

FDA requires that a surgical prep in moist areas – such as the forefoot – reduce bacterial counts by 3 logs. In some studies, patients have been found to have 7+ logs of bacteria in moist sites. So, even if a surgical prep is doing its job by reducing bacteria by 3 logs, there will still be residual bacteria present.

Figure 16



3M™ DuraPrep™ Surgical Solution Drug Facts

Active ingredients

Iodine povacrylex (0.7% available iodine) Antiseptic
Isopropyl alcohol, 74% w/w Antiseptic

Purpose

Uses

patient preoperative skin preparation:

- for preparation of the skin prior to surgery
- helps reduce bacteria that potentially can cause skin infection

Warnings

For external use only. Flammable, keep away from fire or flame. To reduce the risk of fire, PREP CAREFULLY:

- do not use 26 mL applicator for head and neck surgery
- do not use on an area smaller than 8 in. x 10 in.
Use a small applicator instead.
- solution contains alcohol and gives off **flammable vapors**
- do not drape or use ignition source (e.g., cautery, laser) until solution is completely dry (minimum of 3 minutes on hairless skin; up to 1 hour in hair).
- avoid getting solution into hairy areas. **Wet hair is flammable.** Hair may take up to 1 hour to dry.
- do not allow solution to pool
- remove solution-stained material from prep area



Do not use

- on patients with known allergies to iodine or any other ingredients in this product
- on open wounds, on mucous membranes, or as a general skin cleanser
- on infants less than 2 months old due to risk of excessive skin irritation and transient hypothyroidism

When using this product

- keep out of eyes, ears, and mouth. May cause serious injury if permitted to enter and remain. If contact occurs, flush with cold water right away and contact a doctor.
- to avoid skin injury, care should be taken when removing drapes, tapes, etc. applied over film.
- use with caution in women who are breast-feeding due to the potential for transient hypothyroidism in the nursing newborn

Stop use and ask a doctor if irritation, sensitization or allergic reactions occur. These may be signs of a serious condition. On rare occasions, use of this product has been associated with skin blistering.

Keep out of reach of children. If swallowed, get medical help or contact a Poison Control Center right away.

Directions (follow all directions for use)

- at the end of the prep, discard any portion of the solution which is not required to cover the prep area. It is not necessary to use the entire amount available.

Getting Patient Ready for Solution:

- use in well-ventilated area
- do not microwave or heat the solution applicator
- apply to clean, completely dry, residue-free, intact skin
- when hair removal is necessary, use a surgical clipper on the morning of the surgery. If a wet shave is used, thoroughly remove all soap residues.

Activating the Applicator:

For 8635 (6 mL) applicator:

- grasp product by wrapping hand and fingers around the labeled portion of the applicator. Place thumb on the lever.
- with sponge parallel to floor, snap lever. Allow all fluid to flow into sponge.

For 8630 (26 mL) applicator:

- with sponge parallel to the floor, press the cap end of the applicator. Solution will begin to flow into the sponge.
- wait for fluid level to reach indicator line of applicator barrel.

When Applying Solution:

- **DO NOT SCRUB.** Paint a single, uniform application and do not reprep area.
- **do not allow solution to pool.** Use sponge applicator to absorb excess solution and continue to apply a uniform coating. If solution accidentally gets outside of prep area, remove excess with gauze.
- when using the 8630 (26 mL) applicator, clean umbilicus with enclosed swabs when applicable. (Moisten swabs by pressing against solution-soaked sponge applicator.)
- tuck prep towels as needed under both sides of the neck to absorb excess solution. Remove towels before draping.
- avoid getting solution into hairy areas. **Wet hair is flammable.** Hair may take up to 1 hour to dry.
- when prepping skin folds, toes, or fingers, use a sterile-gloved hand to hold skin apart until completely dry. Otherwise, skin may adhere to itself.



After Applying Solution:

- to reduce the risk of fire, **wait until solution is completely dry (minimum of 3 minutes on hairless skin; up to 1 hour in hair).** Solution will turn from a shiny to a dull appearance on skin alerting the user that the solution is completely dry and no longer flammable.

While Waiting for Solution to Completely Dry:

- do not drape or use ignition source (e.g., cautery, laser)
- check for pooled solution. Use sterile gauze to soak up pooled solution. Do not blot because it may remove solution from skin.
- remove solution-stained materials. Replace if necessary.

After Solution is Completely Dry

- to reduce the risk of fire, begin draping and/or using cautery only after solution is completely dry and all solution-stained materials are removed.
- if incise drapes are used, apply directly to dry prep. On completion of surgical procedure, removal of incise drape will remove film.
- apply dressing following standard practices



Other Information store between 20–25°C (68–77°F) • avoid excessive heat above 40°C (104°F) • solution is not water soluble and may stain. Therefore, avoid contact with reusable items (basins, instruments).

Inactive Ingredients ethyl alcohol, water

Questions? call 1-800-228-3957 (Monday to Friday, 7AM – 6PM, CST). www.3M.com.

Effective as of February 2010

3M™ Steri-Drape™ Incise Drapes

Steri-Drape incise drapes create a protective barrier for the patient, reducing the the potential risk of surgical site contamination. Many Steri-Drape drapes also offer fluid control, by channeling and collecting body and irrigation fluids.

The following are summaries of the preclinical and human safety studies conducted to verify the biocompatibility and safety of 3M™ Ioban™ 2 Antimicrobial Incise Drapes.

Preclinical Studies

Cytotoxicity²

Ioban drapes were cut into eight 1-cm² samples. Cultures containing a monolayer of mouse fibroblast cells were prepared for the study. Four pieces of the test article were placed in the quadrants of an agar dish with the adhesive side down, and another four were placed in a second agar dish with the adhesive side up. Cultures were then incubated for 24 hours. The extent of cell lysis under and around the test article was used to determine cytotoxicity.

Results

Ioban drapes were considered non-cytotoxic.

Primary Skin Irritation³

Each of six rabbits received two doses (1-inch x 1-inch squares) of the test article for 24 hours. One test site was intact skin and the other was abraded skin. After sample removal, the test sites were examined and scored for dermal irritation at 1, 24, 48 and 72 hours.

Results

Ioban drapes were considered to be a slight irritant to the intact and abraded skin of rabbits.

Sensitization⁴

A study was conducted to determine the potential of Ioban to promote skin sensitization reactions after repeated applications using a Ritz & Buehler guinea pig method. The study fulfills the sensitization testing requirements in the International Organization for Standardization (ISO) - 10993 standard (2003). Twenty Hartley Albino guinea pigs (treatment group) received 3 six-hour induction applications of Ioban patches over 3 weeks (1 per week). Ten guinea pigs served as naïve controls. Both the treatment and the control groups were challenged with Ioban patches 2 weeks after the third induction on the treatment group. All skin reactions were recorded 24 and 48 hours following patch removals.

Results

The results indicate the Ioban drape is not a potential skin sensitizer.

NOTE: The Ioban drape contains iodine and although sensitization to iodine is low, it is known to occur. Ioban incise drape should not be used on patients with known sensitivity to iodine.

21-Day Cumulative Irritation Potential (HCIPT)⁵

The adhesive side of 3M™ Ioban™ 2 Antimicrobial Incise Drape samples was applied to backs of 12 volunteers. Twenty-four hours later, the samples were removed, sites were evaluated and graded for erythema, and new samples were applied to the same sites. This was repeated daily for a period of 21 days, except on Saturdays and Sundays. Samples applied on Friday were not removed until Monday. An irritation score was calculated by summing each individual's scores on each of 15 evaluation days, adding six scores for Saturdays and Sundays equal to the scores obtained for the following Mondays, and normalizing the data to ten subjects.

Results

Ioban drapes received an irritation classification of “possibly mild under normal use.” This classification is typical for a product with a more aggressive adhesive. The increase in irritation may also be due to skin stripping during the daily removal of the drape samples.

Repeat Insult Patch Test (HRIPT)⁶

Each of 213 volunteers received nine induction applications (three per week for three weeks) of Ioban drape samples on the skin of the upper arm. All induction applications were graded for erythema at 24 or 48 hours after sample removal. A rest period of approximately 2 weeks followed the last induction application. Following the rest period, a challenge application was conducted for 24 hours. The challenge consisted of applying a drape sample to a naïve site located away from the original induction site (i.e. opposite arm) and a simultaneous application to the original site. The challenge sites were graded at 24 and 72 hours after sample removal. Observations of the naïve site provide the basis for interpretation of contact sensitization. Positive reactions at the original site during the challenge phase are not considered significant evidence of sensitization unless confirmed by observations at the naïve site.

Results

Mild to moderate irritation was observed in 19 subjects during the induction phase of the study. Two subjects exhibited responses of mild to moderate erythema with edema during the challenge phase and were subsequently rechallenged. One subject had no visible reaction to the rechallenge drape samples. The second subject did react to the rechallenge drape samples. There were no other indications of contact sensitization during the study.

Although sensitization to povidone-iodine is rare, it is known to occur. The 0.5% (1/213) rate of contact sensitization seen in this study is not unexpected for a product containing iodine.

Human Safety Studies

► Drape Adhesion with 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation Vs ChloroPrep® Patient Preoperative Skin Preparation 2% Chlorhexidine Gluconate (CHG) & 70% Isopropyl Alcohol (IPA) at T=30 Minutes Under Wet Conditions⁷

An incise drape is fully effective only when it's securely adhered to the patient's skin, especially at the wound edge. So it's not surprising that Alexander, et al, found drape lift was associated with a 6-fold increase in surgical site infections.⁸ Good drape adhesion is not a given. The use of different prepping solutions results in varying degrees of drape adhesion. It is important to choose the right prepping solution to get the best drape adhesion.

Purpose

This study compared the drape adhesion of six surgical drapes on skin prepped with either DuraPrep solution or ChloroPrep. The key measure was the adhesion to skin (measured by the force required to remove the drape) after the drapes were exposed to simulated surgical fluid conditions.

Method

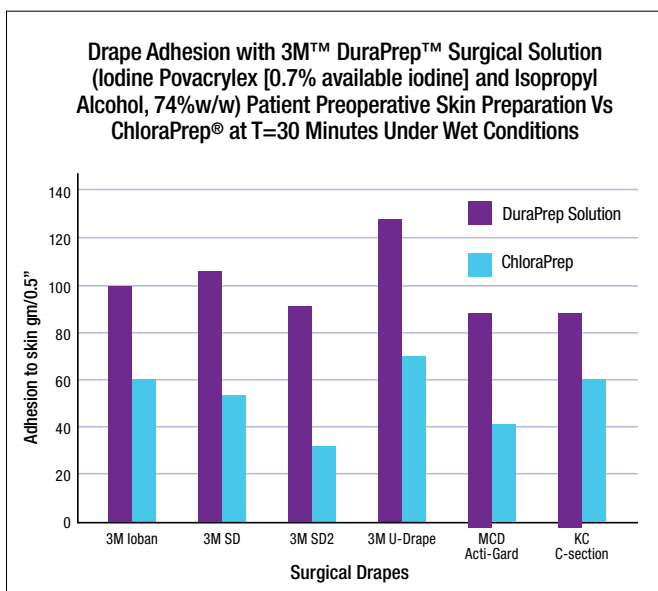
The backs of 36 healthy volunteers were prepped with DuraPrep solution or ChloroPrep according to manufacturer's instructions. The following surgical drapes (2 lots of each drape) were then applied over the dried prepped areas: 3M™ Ioban™ 2 Antimicrobial Incise Drape, 3M™ Steri-Drape™ Incise Drape, 3M™ Steri-Drape™ Incise Drape, 3M™ Steri-Drape™ U-Drape, ACTI-Gard® Antimicrobial Incise Drape by Medical Concepts Development (MCD) and Cesarean/ Abdominal Fluid Collection with Fenestration Drape by Kimberly-Clark (KC). The drape samples were covered with saline-soaked gauze to simulate fluid challenge in surgery, and the drape adhesion to skin value was assessed after 30 minutes.

Results

All surgical drapes tested adhered significantly better ($P<.0001$) to skin prepped with DuraPrep solution as compared to skin prepped with ChloroPrep (Figure 17).

NOTE: This study was designed to assess the overall effects of DuraPrep solution and ChloroPrep on drape adhesion. The test data should not be used to compare the adhesive performance of the individual drapes tested.

Figure 17



► The Plastic Surgical Adhesive Drape: An Evaluation of its Efficacy as a Microbial Barrier

French MLV, Eitzen HE, Ritter MA. The plastic surgical adhesive drape: an evaluation of its efficacy as a microbial barrier. *Ann Surg.* 1976;184(1):46-50.

Purpose

This laboratory experiment was conducted to assess the potential for bacterial build-up and/or migration under the drape. The primary measures were bacterial penetration through the drape and bacterial growth and migration under the drape.

Methods

Backs of volunteers were scrubbed with 70% isopropyl alcohol for five minutes and skin flora samples were taken. Templates measuring 2 in. x 2 in. with a 14mm hole in the center were applied to the test sites. A *Staphylococcus epidermidis* culture was applied into each 14 mm hole, spread evenly and allowed to dry. The template was then removed. Samples of dry and wet cloth drapes and plastic incise drapes were applied to the center of the inoculated area. Rodac impressions were made of each test site after four hours. When the drape samples were removed, the subject's skin and the underside of the drapes were also sampled.

Results

- Bacterial penetration did not occur with the plastic adhesive drape. Penetration did occur with linen drapes, especially when wet.
- Migration studies indicated no lateral movement of bacteria with the adhesive drape. It was not possible to determine migration with the linen drapes since so many bacteria penetrated to the top surface of these drapes.
- Bacterial growth under the adhesive drape was not detected. It was not possible to determine this for cloth drapes.

► Efficacy of Chlorhexidine Gluconate and Povidone Iodine in Combination

Anderson MJ, Lin YC, Parks PJ, Peterson ML. Efficacy of chlorhexidine gluconate and povidone iodine in combination. Poster presented at: 19th Annual Scientific Meeting of the Society for Healthcare Epidemiology of America (SHEA); March 2009; San Diego, CA.

Background

Chlorhexidine gluconate (CHG) and povidone-iodine (PVP-I) are two of the most commonly used antiseptic agents for antimicrobial skin preparation prior to surgery and at intravenous sites. However, the use of CHG and PVP-I in combination is commonly avoided despite a lack of evidence regarding their functional incompatibility. The aim of this study was to determine whether combining CHG with PVP-I would result in antagonism of their bactericidal effects on clinically relevant organisms *in vitro*.

Methods

Serial 2-fold dilutions of aqueous CHG (3% w/vol) and PVP-I (10% w/vol) were prepared across and down microtiter plates. Antiseptic activity at 2 hours was evaluated against clinical strains of *Staphylococcus aureus* (MRSA and MSSA), *Staphylococcus epidermidis*, *Acinetobacter baumannii*, and a laboratory strain of *Escherichia coli* (K12). Bacterial cell densities were determined by serial dilutions and plating. Minimum bactericidal concentration (MBC) was defined as the concentration (% w/vol) that reduced the bacterial counts by $\geq 5 \log_{10}$ CFU/mL in 2 hours. Fractional bactericidal concentration indexes (FBCI) were calculated by the following formula:

$$\frac{(\text{MBC of PVP-I in combination})/(\text{MBC of PVP-I alone}) + (\text{MBC of CHG in combination})/(\text{MBC of CHG alone})}{\text{FBCI}}$$

The results were categorized as follows:

- FBCI < 0.5 (S=synergistic)
- $0.5 \leq \text{FBCI} < 1$ (PS = partially synergistic);
- FBCI = 1 (A=additive)
- $1.0 < \text{FBCI} \leq 4.0$ (I = indifferent); and

- FBCI >4.0 (AN = antagonistic).

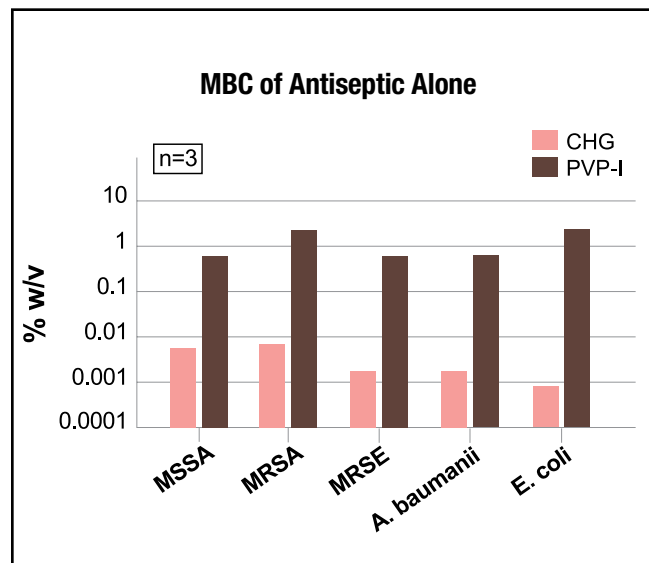
Each organism was tested a minimum of three times.

Results

All tested clinical isolates (*S. aureus*, *S. epidermidis* and *A. baumannii*) were susceptible to CHG (MBC: .0049%, .0024%, .0044%, respectively), and PVP-I (MBC: .73%, .63%, .78%, respectively). *E. coli* K12 was similarly sensitive to CHG (MBC: .0015%) and PVP-I (MBC: 1.25%). CHG showed dose-dependent bactericidal activity, while PVP-I showed an all-or-none mode of action. Overall, combinations of the two antiseptics had no effect on the efficacy of antiseptics in the bacterial strains tested with FBCI = indifferent (Figure 18).

Conclusions: The *in vitro* evidence from this study indicates that combining CHG and PVP-I has no negative impact on antiseptics and suggests that the two antiseptics may be used in combination clinically.

Figure 18



► An *in vitro* Time-Kill Study to Compare the Antimicrobial Activity of Three Antimicrobial Surgical Incise Drapes⁹

Eyberg CE, Morse DJ, Olson LK, Parks PJ. An *in vitro* time-kill study to compare the antimicrobial activity of three antimicrobial surgical incise drapes. Poster presented at: 19th Annual Scientific Meeting of the Society for Healthcare Epidemiology of America; April 2009; San Diego, CA.

Background

Preoperative skin preparations disinfect the superficial layer of the skin. Some residual bacteria may persist and skin flora can recolonize during surgery.¹⁰ Wound contamination has been documented to increase the likelihood of wound infection.^{11,12} Surgeons commonly choose antimicrobial surgical incise drapes in clean and clean-contaminated surgeries as an added protection to lower the potential risk of infection. It is desirable to demonstrate the efficacy of a clinical treatment with a randomized prospective controlled clinical study. However, such a study can be both prohibitively large and costly. *In vitro* time-kill studies are commonly used to assess the effectiveness of an antimicrobial drape.

In this study, the antimicrobial activity of 3M™ Ioban™ 2 Antimicrobial Incise Drape was compared with ACTI-Gard® Antimicrobial Incise Drape and ISODrape™ Incise Drape featuring Microban® antimicrobial protection using an *in vitro* time-kill study based on ASTM E2315-03.⁵ Each drape was tested against 12 microorganisms commonly associated with postoperative infections. This study showed that Ioban drapes reduced all 12 microorganisms better than both Microban® Drape and ACTI-Gard® Drape after an exposure time of 90 minutes.

Purpose

The objective of this study was to measure the antimicrobial activity of three different antimicrobial incise drapes, using an *in vitro* time-kill method. A 3M™ Steri-Drape™ Incise Drape, with no antimicrobial, was used as a control.

Materials and Methods

- An independent test laboratory (MICROBIOTEST) conducted the study based on ASTM E2315-03.¹³
- A suspension of each microorganism with known density was inoculated onto the adhesive side of the sample (approximately 10⁷ CFU/sample).
- At 30, 60 and 90 minutes, the samples were added to a neutralizing broth to stop the antimicrobial activity. The surviving microorganisms were assayed.
- All incise drapes tested are commercially available.
- Six (6) replicate samples of each drape were tested against twelve (12) microorganisms (see Figure 19). All isolates were obtained from the ATCC. No clinical isolates were used.

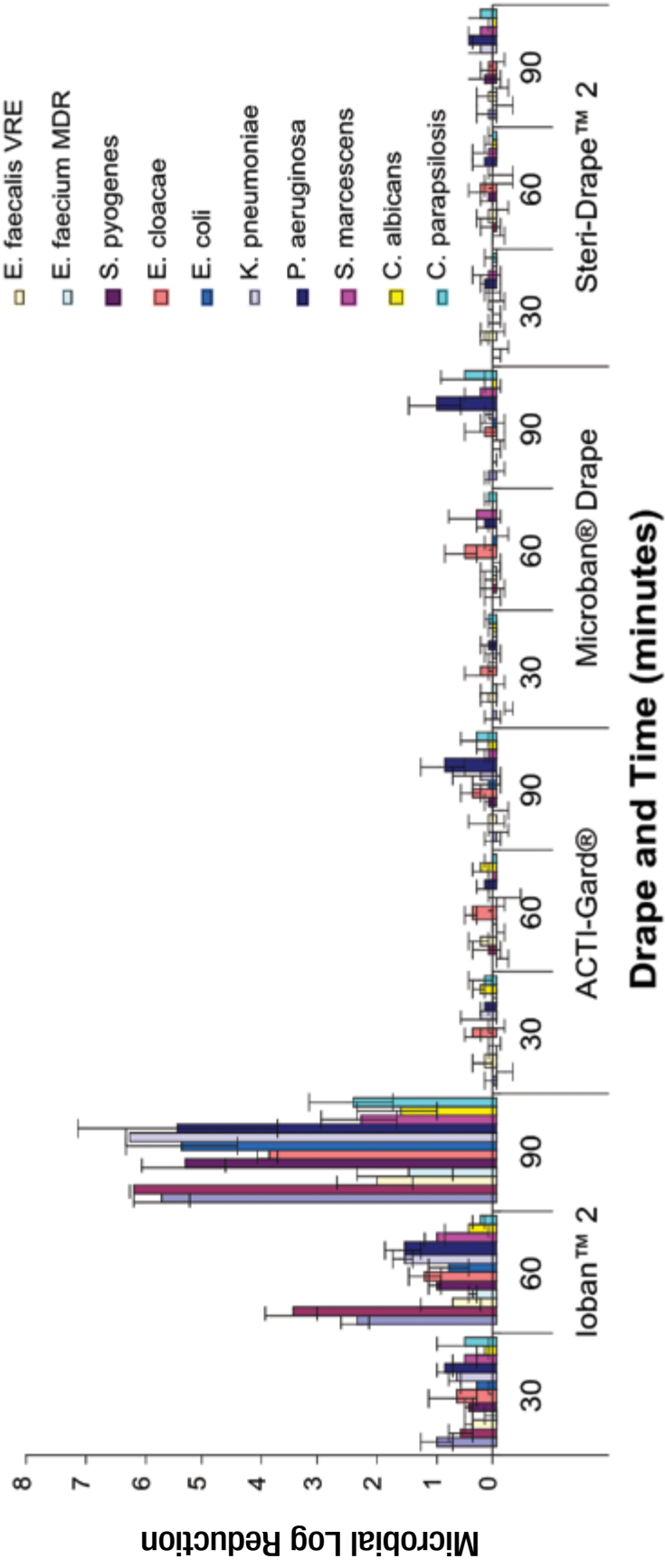
Results

Both exposure time and organism type determined the *in vitro* efficacy of the drapes. Following are the results using Student's t-test. A level of significance of alpha=0.004 was used as an adjustment for the multiple comparisons:

- The log reduction on the Ioban drape was compared against the log reduction on Microban drape and ACTI-Gard drape.
- At no time point, did any of the other drapes kill any of the organisms better than the Ioban drape.
- At 30 minutes of exposure, the Ioban drape was significantly better at reducing the microbial counts for 7 of 12 microorganisms when compared with Microban drape, and 5 of 12 microorganisms when compared with ACTI-Gard drape.
- At 60 minutes, the Ioban drape was significantly better at reducing the microbial counts for 9 of 12 microorganisms when compared with Microban drape, and 10 of 12 microorganisms when compared with ACTI-Gard drape.
- At 90 minutes, the Ioban drape was significantly better at reducing the microbial counts when compared with the other two antimicrobial drapes for all 12 microorganisms.
- The Ioban drape was shown to significantly reduce MRSA and MRSE, which are organisms frequently associated with increased incidence of surgical site infections and morbidity in surgeries commonly using incise drapes.¹⁴

Figure 19

In vitro Time-Kill



Note: There are no error bars shown when no organisms were recovered at a time point

► Plastic Iodophor Drape During Liver Surgery Operative Use of the Iodophor-impregnated Adhesive Drape to Prevent Wound Infection during High Risk Surgery

Yoshimura Y, Kubo S, Hirohashi K, Ogawa M, Morimoto K, Shirata K, Kinoshita H. Plastic iodophor drape during liver surgery operative use of the iodophor-impregnated adhesive drape to prevent wound infection during high risk surgery. *World J Surg.* 2003;27(6):685-688.

Purpose

A retrospective study to evaluate the various risk factors associated with wound infection after liver resection for hepatocellular carcinoma (HCC). The use of an iodophor-impregnated adhesive drape (3M™ Ioban™ 2 Antimicrobial Incise Drape) to prevent wound infection was evaluated.

Methods

This was an investigator-initiated retrospective study. Data on liver resection for HCC from April 1994 to the end of 2001, a span of 7 years, were reviewed. All operative procedures were classified as “clean-contaminated” according to the guidelines of the Centers for Disease Control and Prevention. Factors that potentially influence postoperative wound infection investigated in this study included: use of Ioban incise drapes versus no incise drape used, age, gender, body mass index (BMI), alcohol abuse, smoking, systemic steroid use, diabetes mellitus, duration of preoperative hospital stay, operating time, intraoperative blood loss, etc. The primary end point of the study was wound infection, which was defined as purulent drainage from the superficial incision with or without laboratory confirmation. The presence or absence of wound infection was recorded up to 30 days after surgery. The risk factors were compared using Student’s t-test, Fisher’s exact test and Mann-Whitney U-test. The risk factors for wound infection were evaluated using multiple regression analysis.

Results

A total of 296 patients who underwent liver resection for HCC were identified. Based on the multiple regression analysis, the factors that were significantly associated with wound infections were: low body mass index, smoking, long preoperative hospital stay, and lack of Ioban drape use (see Table 1). Wound infection was significantly less likely with Ioban drape use (4/122 or 3.1%) than for surgery without Ioban drape (21/174 or 12.1%), $P=0.0218$. Ioban drapes appear to be useful for decreasing the wound infection rate by preventing intraoperative contamination with skin bacteria, although a prospective study is necessary to obtain any definitive conclusions.

Table 16: Risk factors for wound infection after liver resection for hepatocellular carcinoma calculated using multiple regression analysis

Variables	P Values
BMI	0.0006
Smoking	0.0422
Preoperative Hospital Stay	0.0747
Operating Time	0.997
Intraoperative Blood Loss	0.388
Ioban Use	0.0218

▶ The Relative Importance of Routes and Sources of Wound Contamination During General Surgery.

Whyte W, Hambræus A, Laurell G, Hoborn J. The relative importance of routes and sources of wound contamination during general surgery. I. Non-airborne. *J Hosp Inf.* 1991;18(2):93-107.

Purpose

The purpose of this study was to investigate the relative importance of routes and sources of wound contamination during general surgery. The key measures were bacterial sampling of the skin, wound, bile and glove tips. Observation of fluid strikethrough on surgical gowns was also recorded.

Methods

A total of 188 patients undergoing biliary tract surgery were studied over a 100-week period. The operative site was prepped with 0.5% chlorhexidine in 70% ethanol. The first 52 patients were draped with four disposable drapes. A 3M™ Steri-Drape™ Incise Drape was used for the remainder of the study. Skin was sampled at the incision site prior to skin preparation.

The wound was sampled intraoperatively in six different areas of the visceral layer/wound wall. Bile was aspirated into a syringe by puncturing the gall bladder prior to removal.

All available gloves used by surgeons and assistants were sent to the lab for processing. Throughout the study the surgical team wore cotton or disposable gowns on alternating weeks. The distance blood and fluid had penetrated up the inside of the cuff was measured. An estimate of the dampness of the surgeon's shirt and trousers was considered evidence of fluid passing through the gown.

Results

- “When the bile was infected, bacteria from the bile accounted for most of the bacteria in the wound (>99%). However, when the bile was sterile, it was determined that the patient's skin contributed a significant number of bacteria to the wound.”
- A significant correlation ($P < .001$) was demonstrated between high skin counts and high wound counts.
- The use of an incise drape was shown to reduce wound contamination by approximately one-third on the visceral layer of the liver when no bile bacteria were present.

▶ Skin Preparations in CABG Surgery: A Prospective Randomized Trial

Roberts AJ, Wilcox K, Devineni R, Harris RB, Osevala MA. Skin preparations in CABG surgery: a prospective randomized trial. *Comp Surg.* 1995;14(6):724-751.

Purpose

The purpose of this clinical trial was to compare the efficacy of two commercially-available preps 3M™ DuraPrep™ Surgical Solution (Iodine Povacrylex [0.7% available iodine] and Isopropyl Alcohol, 74% w/w) Patient Preoperative Skin Preparation and E-Z Scrub™ detergent and paint (Parke Davis, Sandy, Utah), along with the use of 3M™ Ioban™ 2 Antimicrobial Incise Drapes. The key measures in this study were skin prep time, visibility of the prep, incise drape adhesion and incidence of wound infections.

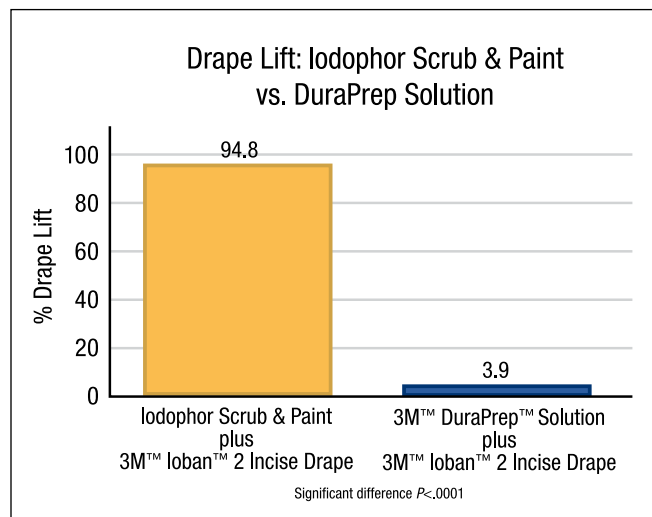
Methods

A total of 200 patients undergoing coronary artery bypass graft surgery (CABG) were randomly assigned to one of two study groups. The experimental group was treated with DuraPrep solution on the chest and legs plus an Ioban 2 incise drape on the chest. The control group received a traditional 5-10 minute scrub of the chest and legs, followed by an iodophor paint. Again, Ioban 2 drapes were applied to the chest. The prepping time was recorded from the beginning of the prepping procedure until the chest and legs were ready for incision. Visibility of the prep and drape adhesion were recorded at the end of surgery. Wounds were considered infected if purulent material drained from the incision site.

Results

- There were no differences in postoperative wound infection rates between the two study groups.
- Incise drape adhesion was significantly better ($P<.0001$) in the experimental group, where drape lift occurred in only 3.9% of the cases compared to 94.8% in the control group. (See Figure 20).
- The percentage of patients with visible skin prep at the end of surgery was significantly higher ($P<.0001$) in the experimental group prepped with DuraPrep solution (99%) compared to the control group (6.3%).

Figure 20



► The Efficacy of Adhesive Plastic Incise Drapes in Preventing Wound Contamination

Ha'eri GB. The efficacy of adhesive plastic incise drapes in preventing wound contamination. *Int Surg.* 1983;68(1):31-32.

Purpose

This study was conducted to determine the value of incise drapes in preventing bacteria from migrating into the surgical wound. The primary measure in this study was the collection of wound irrigates.

Methods

3M™ Steri-Drape™ Incise Drapes were used on 30 patients undergoing screw-plate fixations or unipolar arthroplasties for femur fractures. All patients were prepped with a three-minute skin scrub using Betadine solution. The prep was allowed to air dry and residual iodophor was wiped with alcohol. After drying, the skin was sprayed with a suspension containing Human Albumin Microspheres (HAM) one inch away from the incision line. This simulated bacterial indicator suspension was allowed to dry, the surgical site was squared off and a plastic incise drape was applied. At the end of the surgical procedure, wound irrigates were collected to retrieve HAM particles that may have migrated into the wound. The irrigates were centrifuged, washed and stained for identification under the microscope.

Results

In all 30 cases the investigators were unable to identify HAM particles (simulated bacterial indicators) in any wound irrigates.

► Retrospective Evaluation of an Iodophor-Incorporated Antimicrobial Plastic Adhesive Wound Drape

Ritter MA, Campbell ED. Retrospective evaluation of an iodophor-incorporated antimicrobial plastic adhesive wound drape. *Clin Orthop Relat Res.* 1988;(228):307-308.

Purpose

The purpose of this retrospective study was to evaluate the clinical capability of an iodophor-impregnated film to achieve the primary objective of a surgical drape (i.e., reduce the possibility of post-op wound infections). The primary endpoint was incidence of wound infection.

Methods

From Jan 1982 – Dec 1984, 3M™ Ioban™ 2 Antimicrobial Incise Drapes were routinely applied in conjunction with a one-minute alcohol cleanse. Data from total arthroplasty surgeries within this period were reviewed. Patients with previously infected total arthroplasties were excluded. The patients were followed for a minimum of 1 year after surgery to detect any indication of postoperative infection which consisted of a draining wound and/or a positive culture from the joint.

Results

A total of 649 total arthroplasty surgeries using Ioban drape and a 1-minute alcohol cleanse for preoperative skin preparation were identified. Only 3 postoperative infections (0.46%) were encountered. This was comparable to the 0.42% infection rate observed in a previous clinical study using a conventional polymer-iodine spray as a skin preparation.¹⁵ This study showed that Ioban drapes, when used with a preliminary alcohol cleanse, are an excellent method of surgical skin preparation. The use of the Ioban drape only required a one-minute alcohol cleanse, eliminating the requirement for a preliminary antiseptic scrub, thus providing time and cost savings.

► The Use of an Iodophor-Impregnated Plastic Incise Drape in Abdominal Surgery: A Controlled Clinical Trial

Dewan PA, Van Rij AM, Robinson RG, Skeggs GB, Fergus M. The use of an iodophor-impregnated plastic incise drape in abdominal surgery--a controlled clinical trial. *Aust N Z J Surg.* 1987;57(11):859-863.

Purpose

The purpose of this study was to conduct a prospective randomized trial comparing the efficacy of 3M™ Ioban™ 2 Antimicrobial Incise Drapes to a standard skin preparation technique in abdominal surgeries. The primary endpoints of the study were bacterial wound contamination and wound infection rates.

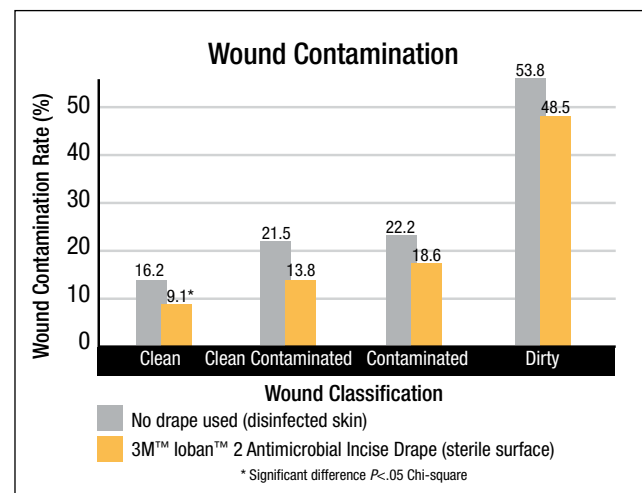
Methods

Abdominal surgery patients were randomly assigned to either receive the Ioban drape or enter the control group, (receive no Ioban drape). All patients were given a routine skin prep consisting of an iodophor antiseptic followed by alcohol. The Ioban drape was then applied to those patients designated to the test group. At completion of the operative procedure, and following closure of the deep fascia, a bacterial swab sample was taken and cultured for aerobic and anaerobic organisms.

Results

- A total of 1,016 abdominal patients completed the trial.
- Wound infection rates were not found to be significantly different between the two study groups.
- Wound contamination occurred in 6.2% of patients draped with Ioban drapes compared with 10.3% of all wounds without the drape ($P < .03$).
- In clean wounds (219 patients total) there was a significant difference in wound contamination. Contamination occurred in 9.1% of the patients draped with Ioban drapes compared with 16.2% of the patients without drapes ($P < .05$). (See Figure 21).

Figure 21





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