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ORIGINAL RESEARCH

Criticality of Benzoyl Peroxide and Antibiotic Fixed Combinations in Combating Rising Resistance in *Cutibacterium acnes*

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Background: Antibiotic resistance is growing globally, with multiple countries reporting resistance in >50% of *Cutibacterium acnes* (*C. acnes*) strains. Combination formulations of an antibiotic and the antimicrobial benzoyl peroxide (BPO) may reduce this resistance risk, especially with prolonged use. This 4-part study tested susceptibility of 31 *C. acnes* clinical strains and development of resistance to antibiotics alone or combined with BPO.

Methods: *C. acnes* susceptibility to single-drug antibiotics was assessed via minimum inhibitory concentration (MIC) values obtained from epsilometer tests, with lower MIC indicating higher susceptibility. Susceptibility to fixed-dose antibiotic/BPO combination products was determined by measuring the zone of inhibition using the agar diffusion method, with larger diameter indicating increased bacterial inhibition. The effect (synergistic, additive, antagonistic, or indifferent [no interaction]) of combining clindamycin with BPO on *C. acnes* inhibition was evaluated using a checkerboard assay, wherein 2 test compounds are combined in varying concentrations. Resistance development was assessed using serial passage of bacterial cultures in increasing concentrations of clindamycin alone or in combination with BPO.

Results: All tested antibiotics (clindamycin, doxycycline, erythromycin, and minocycline) exhibited similar activity. *C. acnes* susceptibility was variable, with some strains having elevated MIC values—an indication of resistance—against different antibiotics. For 6 strains resistant to clindamycin alone (inhibitory zone=0 cm), formulations with BPO enhanced activity against the same isolates (range: 0.8–2.2 cm). Of 7 acne-associated strains, combining clindamycin and BPO had an additive effect against 4, and no interaction against 3. Bacterial cultures repeatedly exposed to the combination of clindamycin and BPO did not develop antibiotic resistance, which occurred with exposure to clindamycin alone.

Conclusion: Overall, antibiotic susceptibility was highly dependent on the *C. acnes* strain, and antibiotic formulations with BPO exhibited enhanced activity against less susceptible strains. Fixed combinations of BPO with an antibiotic may improve antimicrobial activity and protect against resistance development.

Keywords: acne, antibiotics, benzoyl peroxide, clindamycin, combination treatment, *C. acnes*, resistance, susceptibility

Introduction

Clindamycin and other antibiotics were among the first effective treatments for acne; accordingly, dermatologists prescribe almost 5% of all antibiotics, though they account for ≤1% of the US physician population.[1] However, recent acne management guidelines discourage the use of antibiotics as monotherapy due to the development of bacterial resistance.[2,3] Resistance to topical antibiotics in *Cutibacterium acnes* (*C. acnes*; previously *Propionibacterium acnes*)—

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the bacteria involved in acne pathogenesis—was first reported in the US in the 1970s.[4] Since then, several countries have reported >50% of *C. acnes* strains as resistant to certain antibiotics.[5,6]

This emergence of resistant strains can lead to increased acne therapeutic failure.[7] A systematic review of 14 clinical trials showed a decrease in the efficacy of topical erythromycin in treating acne lesions over a 10-year time period that coincided with an increase in *C. acnes* resistance to erythromycin.[8] Moreover, the clinical implication of *C. acnes* resistance development from prolonged antibiotics use can extend beyond acne treatment: resistance genes can be transferred from *C. acnes* to pathogenic bacterial strains such as staphylococci and streptococci. In a study examining the effects of topical and/or oral antibiotics on oropharyngeal flora in patients with acne, antibiotic-treated patients were at greater risk of colonization by potentially pathogenic *Streptococcus* bacteria.[9,10] Furthermore, 85% of *Streptococcus* cultures from these antibiotic-treated patients were resistant to at least one antibiotic, versus 20% in patients without a history of antibiotic use.[10] Topical erythromycin use is associated with an increase in antibiotic-resistant *Staphylococcus* bacteria,[11–13] including strains that can be pathogenic in certain patient populations.[14]

Given the danger of a global rise in antibiotic resistance, a National Action Plan to slow the emergence of resistant bacteria has been instituted by the US Centers for Disease Control and Prevention,[15] and dermatology-specific guidelines on antibiotic stewardship have been proposed by the Scientific Panel on Antibiotic Use in Dermatology of the American Acne and Rosacea Society.[16,17]

Combination formulations containing an antibiotic and benzoyl peroxide (BPO) can reduce the risk of resistance, especially with prolonged use.[3] Importantly, to date, there is no evidence of *C. acnes* resistance to BPO.[18] Additionally, combination therapies are generally more efficacious than monotherapies for the treatment of acne.[19] For example, clinical studies and a network meta-analysis have demonstrated that fixed-dose clindamycin/BPO has greater efficacy than monotherapy with either BPO or clindamycin.[20–22] Currently, there are several approved fixed-combination topical acne therapies containing an antibiotic and BPO.[23–29]

Given the constantly evolving landscape of antibiotic resistance, it is important to confirm BPO's pivotal role in the acne armamentarium against *C. acnes* strains. This 4-part study tested the susceptibility of *C. acnes* strains and the development of resistance to antibiotics alone or in combination with BPO.

Materials and Methods

The study was composed of 4 parts, evaluating 31 individual clinical strains of *C. acnes* received in 2022 (obtained through Biodefense and Emerging Infections Research Resources, National Institute of Allergy and Infectious Diseases, and National Institute of Health as part of the Human Microbiome Project; Figure 1, Supplemental Table 1). Strains were selected to ensure the inclusion of those from different classes and susceptibility profiles as well as different associations

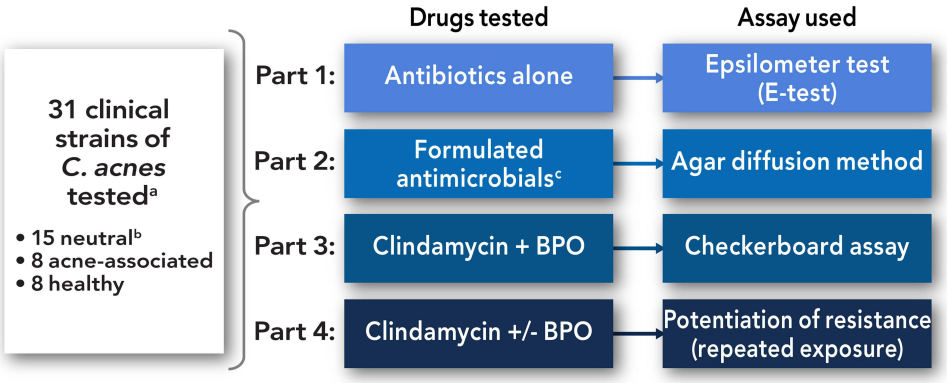

Figure 1 Study design. This 4-part study tested susceptibility of 31 *C. acnes* clinical strains and development of resistance to antibiotics alone or in combination with BPO.
Notes: [a]Classification based on Fitz-Gibbon S, et al. *J Invest Dermatol*. 2013;133(9):2152–60.[30] "Neutral" is reported to cause acne but also colonize normal skin, "acne-associated" colonize skin with acne, and "healthy" colonize healthy skin. [b]Includes 1 strain sometimes classified as acne-associated. [c]Comprising 6 branded products: CLIN 1.2%/adapalene 0.15%/BPO 3.1% (Ortho Dermatologics), Clindamycin 1% gel (Ortho Dermatologics), CLIN 1.2%/BPO 3.75% gel (Ortho Dermatologics), minocycline 4% foam (Journey Medical Corporation), CLIN 1.2%/BPO 5% gel (Stiefel Laboratories), erythromycin 3%/BPO 5% gel (Ortho Dermatologics).
Abbreviations: BPO, benzoyl peroxide; CLIN, clindamycin phosphate.

with acne, including acne-associated (ie, strain is associated with acne), healthy (ie, strain has not been identified as being related to acne), or neutral (ie, strain may be found in healthy or acne-associated skin). All study results were summarized using descriptive statistics.

Part 1: *C. acnes* Susceptibility to Antibiotics

C. acnes susceptibility to single-drug antibiotics was assessed via minimum inhibitory concentration (MIC) values obtained from epsilometer tests (E-test; Figure 2A). MIC is the lowest concentration of an antibiotic needed to inhibit bacterial growth, with lower MIC indicating higher susceptibility. The E-strip is a plastic strip with an antibiotic gradient concentration immobilized on one side and the MIC interpretative scale printed on the other side. The E-test MIC is defined as the point on the scale at which the ellipse of growth inhibition intercepts the strip.

A total of 31 *C. acnes* strains—including 15 neutral isolates, 8 acne-associated isolates, and 8 healthy isolates (Figure 1 and Supplemental Table 1)—were cultured on Brucella blood agar (BBA) and incubated at 37°C for 48 hours under anaerobic conditions. The bacterial inoculum was prepared by suspending the microbial cells in demineralized water and adjusted to a density of 1.0 McFarland. A cotton swab was used to spread the inoculum evenly onto the BBA plate, followed by the application of the E-test strips of the 4 test antibiotics placed separately on the surface of the inoculated BBA plates. The MICs were recorded 48 hours after incubation at 37°C under anaerobic conditions.

Data interpretation was performed according to the recommendations of the Clinical and Laboratory Standards Institute (CLSI) and the National Committee for Clinical Laboratory Standards (CLSI Document #M11-A7). There was no observed CLSI breakpoint for any of the test compounds against *C. acnes*; therefore, isolates that had higher MIC values against the test products were considered less susceptible and designated as having elevated MIC (Supplemental Table 2). Data were recorded in the form of MIC range, MIC_{50} (the concentration that inhibited 50% of the isolates tested), and MIC_{90} (the concentration that inhibited 90% of the isolates tested).

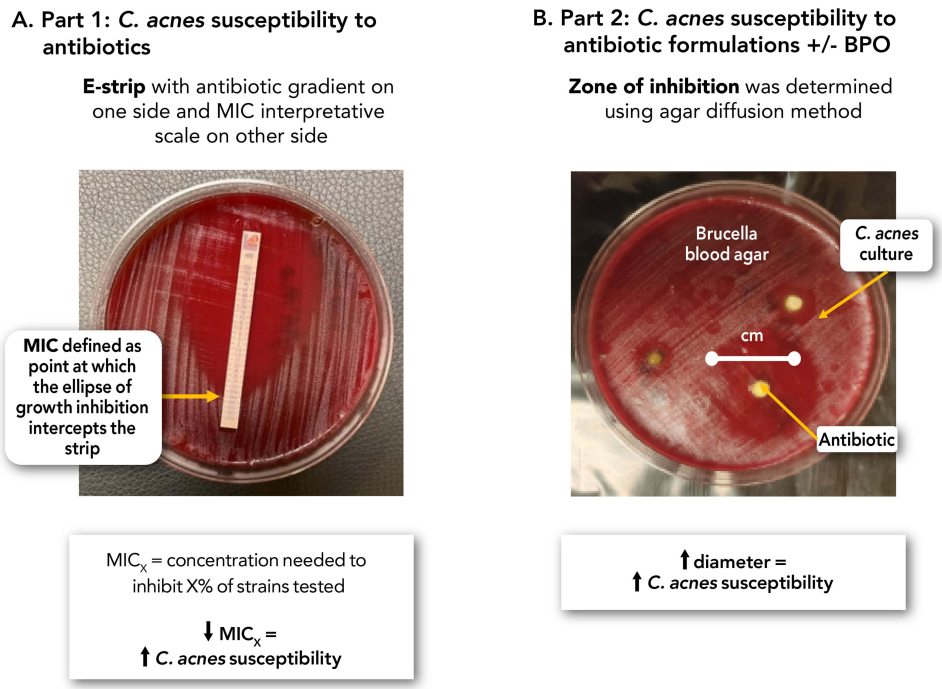

Figure 2 Study methods: estimation of MIC. (**A**) MIC measurement by E-strip. (**B**) MIC measurement by agar diffusion method.
Abbreviations: E-strip, Epsilometer strip; MIC, minimum inhibitory concentration.

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Part 2: *C. acnes* Susceptibility to Antibiotic Formulations ± BPO

Susceptibility to fixed-dose antibiotic/BPO combination products versus antibiotic formulations without BPO was compared by measuring the zone of inhibition using the agar diffusion method, with a larger diameter indicating increased bacterial inhibition (Figure 2B). The branded antibiotics assessed included 1 foam and 5 gel formulations. Following the growth of all 31 *C. acnes* isolates (Supplemental Table 1) at 37°C for 48 hours under anaerobic conditions, the inoculum was standardized to 0.5 McFarland. Next, 2 BBA plates were inoculated with the organisms at the appropriate dilution. On each plate, three wells of 4 mm size were created, and 20 µL of one of the formulated drugs was added to the wells; plates were incubated under anaerobic conditions at 37°C for 48 hours. The diameter of each zone of inhibition was measured and recorded.

Part 3: Effect of Clindamycin + BPO on *C. acnes* Inhibition

The effect (synergistic, additive, antagonistic, or indifferent [ie, no interaction]) of combining clindamycin with BPO on the inhibition of *C. acnes* strains was evaluated using a checkerboard assay as previously described,[31] wherein 2 test compounds are combined at varying concentrations (Figure 3A). Seven acne-associated strains were evaluated, including 1 neutral strain that is sometimes classified as acne-associated and excluding 2 strains that were difficult to grow in the medium required for *C. acnes*. Brain Heart Infusion broth supplemented with 0.05% Tween 80 and 1% glycerol was used

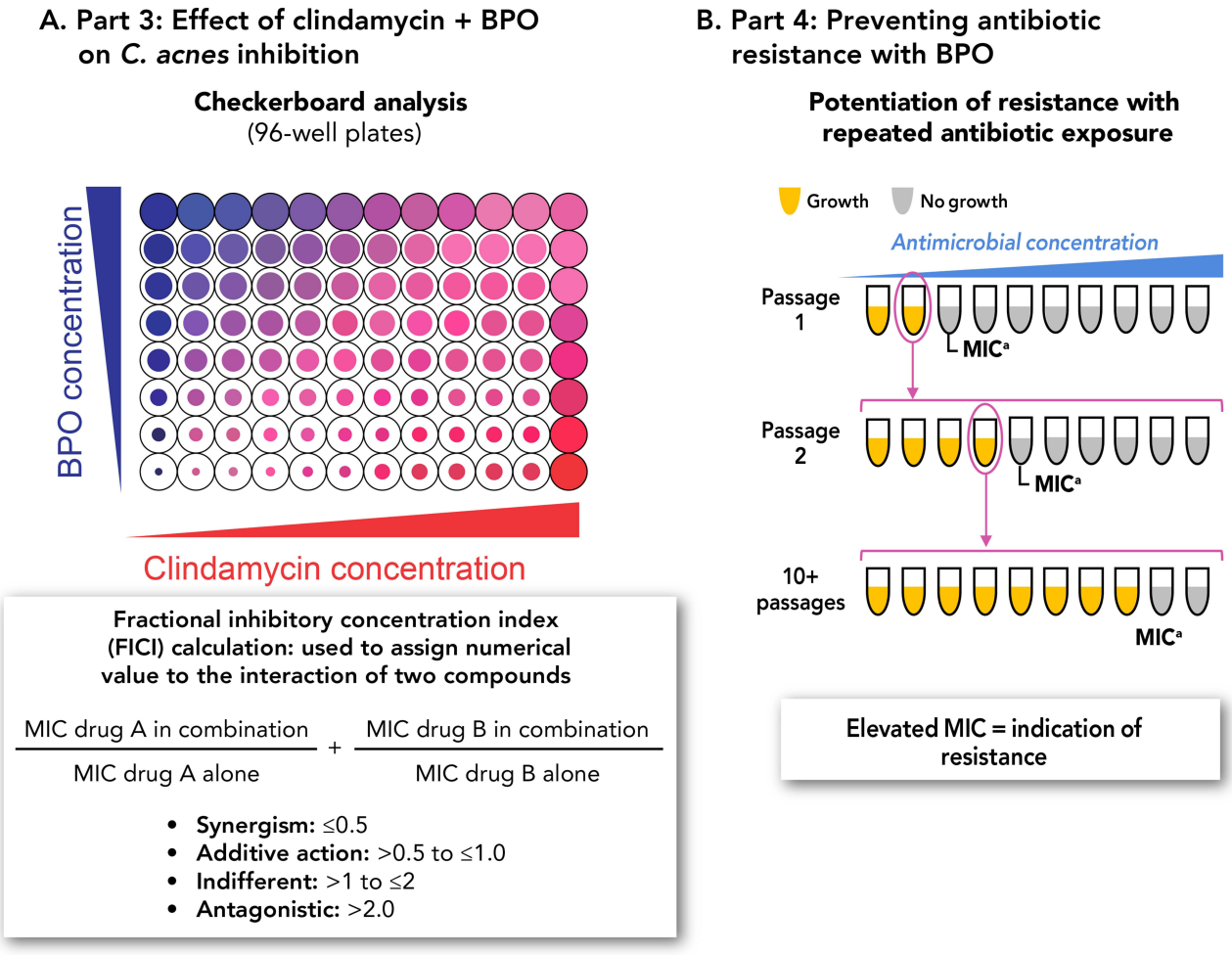

Figure 3 Study methods: analyzing combination of clindamycin + BPO. (**A**) Evaluation of the effect of combining clindamycin with BPO using checkerboard assay. (**B**) Evaluation of antibiotic resistance development by serial passage of bacterial cultures.
Notes: [a]MIC is determined to be the lowest concentration in which no growth is observed.
Abbreviations BPO, benzoyl peroxide; MIC, minimum inhibitory concentration.

for the checkerboard test, and a final concentration of 1×10^5 colony forming units/mL was inoculated. The MICs of the drugs alone and in combination were determined after incubation at 37°C for 48 hours under anaerobic conditions. Combination testing is evaluated based on the fractional inhibitory concentration index (FICI), which assigns a numerical value to the interaction of the 2 compounds. The FICI is calculated using the following formula:

$$\frac{\text{MIC drug A in combination}}{\text{MIC drug A alone}} + \frac{\text{MIC drug B in combination}}{\text{MIC drug B alone}}$$

Interpretation of the FICI for the combination of compounds is defined as follows: synergism ≤0.5, additive action >0.5 to ≤1.0, antagonistic >2.0, indifferent >1 to ≤2.

Scanning Electron Microscopy of Clindamycin + BPO

The effect of clindamycin and BPO alone and in combination on the morphology and ultrastructure of *C. acnes* strain HL053PA2 was determined using scanning electron microscopy (SEM) as described previously.[32] Briefly, *C. acnes* were exposed to clindamycin or BPO alone and in combination for 48 hours. Two hundred microliters of cell suspension were fixed in 2% glutaraldehyde and incubated at 4°C for 48 hours. After fixation, samples were processed and dried. Processed samples were coated with palladium for 60 seconds and viewed with the Nova NanoLab 200 FEG-SEM/FIB scanning electron microscope in high-vacuum mode at 2.00 kV. Untreated cells were included as controls for each strain. All compounds were tested at 1× the respective MIC determined by checkerboard assay.

Transmission Electron Microscopy of Clindamycin + BPO

The effect of clindamycin and BPO alone and in combination on the morphology and ultrastructure of *C. acnes* strain HL053PA2 was determined using transmission electron microscopy (TEM). *C. acnes* exposed to clindamycin (2 µg/mL) or BPO (32 µg/mL) alone and in combination were fixed with 2.5% glutaraldehyde for 2 hours, placed in 2% potassium permanganate for 2 hours at 4°C, and washed 5 times with distilled water. Cells were subsequently exposed to 1% potassium dichromate and 1% uranyl acetate for 2 hours at 4°C, followed by several washes with distilled water. Samples were then embedded in agar, left to set, cut into small cubes (0.5–1 mm^3), and dehydrated through an ethanol series. The 100% ethanol was replaced with propylene oxide twice for 20 minutes, and the sample was then embedded in Epon by graded impregnation. Sections were obtained using an ultramicrotome, counterstained with lead citrate, and observed under a transmission electron microscope as described previously.[33] Overnight untreated cultures were processed in parallel for TEM analyses as a control. Images captured for each set of samples were analyzed for morphological and ultrastructural changes.

Part 4: Preventing Antibiotic Resistance with BPO

The development of resistance in 3 acne-associated strains that were highly susceptible to clindamycin was assessed using serial passage of bacterial cultures in increasing concentrations of clindamycin alone or in combination with BPO (Figure 3B). The MIC of clindamycin alone and in combination with BPO was determined by the microdilution method. Inocula were prepared to a 0.5 MacFarland standard from a 48-hour growth on anaerobic blood agar. Incubations were performed at 37°C under anaerobic conditions. MIC results were interpreted per CLSI guidelines.[34] From this initial MIC determination, the contents of the microdilution well at 0.5 MIC—a sub-inhibitory concentration that is one dilution lower than that showing bacterial inhibition as compared with the growth control—were then transferred to a BBA medium using spot inoculation and streaked for isolation. Inocula from this subculture were tested using the microdilution test at concentrations of the antibiotic at 0.5 MIC, 1 MIC, 2 MIC, 4 MIC, and 8 MIC for a total of 12 times. MIC determinations were performed on the growth obtained from each passage. A rise in MIC of ≥3-fold the original value for each isolate indicated the development of resistance to the antibiotic (alone or in combination with BPO).

Results

Part 1: *C. acnes* Susceptibility to Antibiotics

All antibiotics tested—erythromycin, clindamycin, doxycycline, and minocycline—had generally similar MIC ranges, indicating similar activity against most *C. acnes* strains tested (Table 1). Erythromycin had a higher MIC_{90} (>256 µg/mL)

Table 1 Antibiotic Susceptibility of *C. acnes* Strains Using an E-Test

µg/mL	MIC Range	MIC_{50}	MIC_{90}
Minocycline	0.023–3	0.094	1
Erythromycin	<0.016 – >256	0.023	>256
Doxycycline	0.023–6	0.094	3
Clindamycin	<0.016 – >256	0.047	16

Abbreviations: E-test, Epsilometer test; MIC, minimum inhibitory concentration.

compared with other antibiotics (range: 1–16 µg/mL), indicating a higher concentration of drug required to inhibit 90% of tested strains. Five *C. acnes* strains had elevated MIC to multiple antibiotics tested, an indication of resistance (Supplemental Table 3). Specifically, 3 strains (HL053PA1, HL045PA1, HL056PA1) had elevated MIC against all antibiotics tested, 1 strain (HL013PA1) had elevated MIC against clindamycin and erythromycin, and 1 strain (HL038PA1) had elevated MIC against all antibiotics except clindamycin, suggesting that susceptibility pattern is strain dependent.

Part 2: *C. acnes* Susceptibility to Antibiotic Formulations ± BPO

All antimicrobial formulations tested produced similar ranges of zones of inhibition, indicating similar activity against the *C. acnes* strains (Figure 4A). Six *C. acnes* strains (HL005PA1, HL056PA1, HL045PA1, HL043PA1, HL013PA1, HL053PA1) had no inhibitory zone (0 cm) with clindamycin 1%, indicating resistance to clindamycin. However, when these 6 strains were exposed to fixed-dose formulations of clindamycin/BPO, enhanced antibacterial activity was observed, with inhibitory zones ranging from 0.8 to 2.2 cm (Figure 4B).

Part 3: Effect of Clindamycin + BPO on *C. acnes* Inhibition

The combination of clindamycin and BPO resulted in an additive effect for 4 of 7 acne-associated strains tested (FICI: 1) and had no interaction for 3 strains (FICI: 2; Supplemental Table 4). Microscopic images from separate in vitro experiments confirmed this finding (Figure 5). SEM, which produces three-dimensional images of the cell surface,[35] showed that clindamycin+BPO resulted in massive cell leakage, as well as cytoplasmic leakage with intracellular debris,

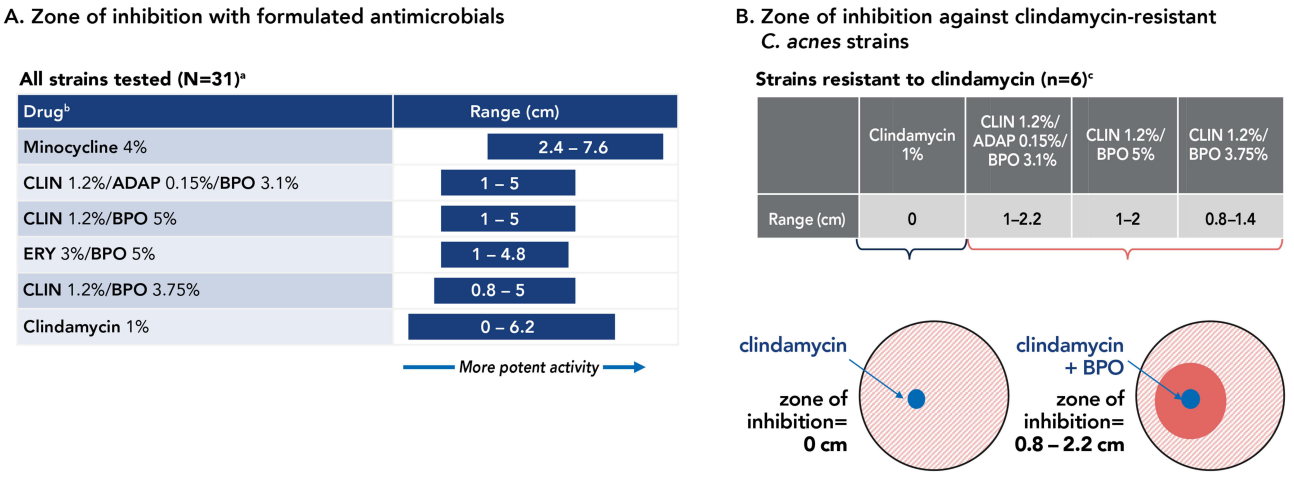

Figure 4 *C. acnes* sensitivity to clindamycin compared with clindamycin/BPO. (**A**) Formulated antimicrobials possessed similar activity against most *C. acnes* strains. (**B**) Formulations containing BPO had enhanced activity against those strains that had no inhibitory zone with clindamycin alone.
Notes: [a]Refer to Supplemental Table 1 for a full list of strains tested. [b]All drugs are branded formulations. [c]Strains that had a 0 cm zone of inhibition to clindamycin alone: HL005PA1, HL056PA1, HL045PA1, HL043PA1, HL013PA1, HL053PA1.
Abbreviations ADAP, adapalene; BPO, benzoyl peroxide; CLIN, clindamycin phosphate; ERY, erythromycin.

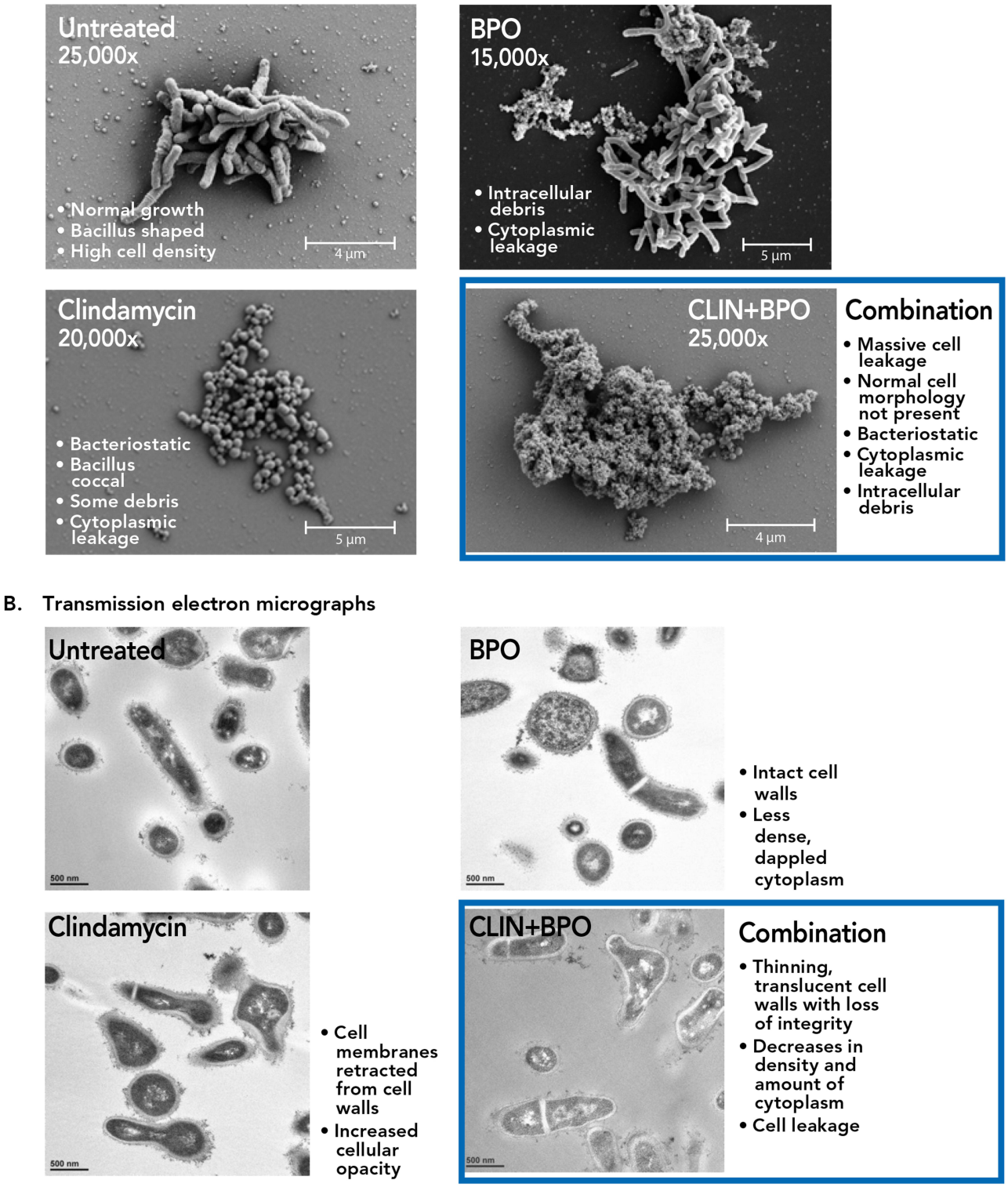

Figure 5 Scanning and transmission electron microscopy of clindamycin + BPO. (**A**) Scanning electron micrographs and (**B**) transmission electron micrographs demonstrated increased cell leakage with clindamycin+BPO, suggesting combination treatment may have additive effects. Transmission electron micrographs are provided for 2 µg/mL clindamycin and 32 µg/mL BPO. At higher concentrations (4 µg/mL clindamycin and 64 µg/mL BPO), additive effect of drugs on *C. acnes* was not discernable as the effects of individual drugs on *C. acnes* morphology was maximal (data not shown).
Abbreviations: BPO, benzoyl peroxide; CLIN, clindamycin phosphate.

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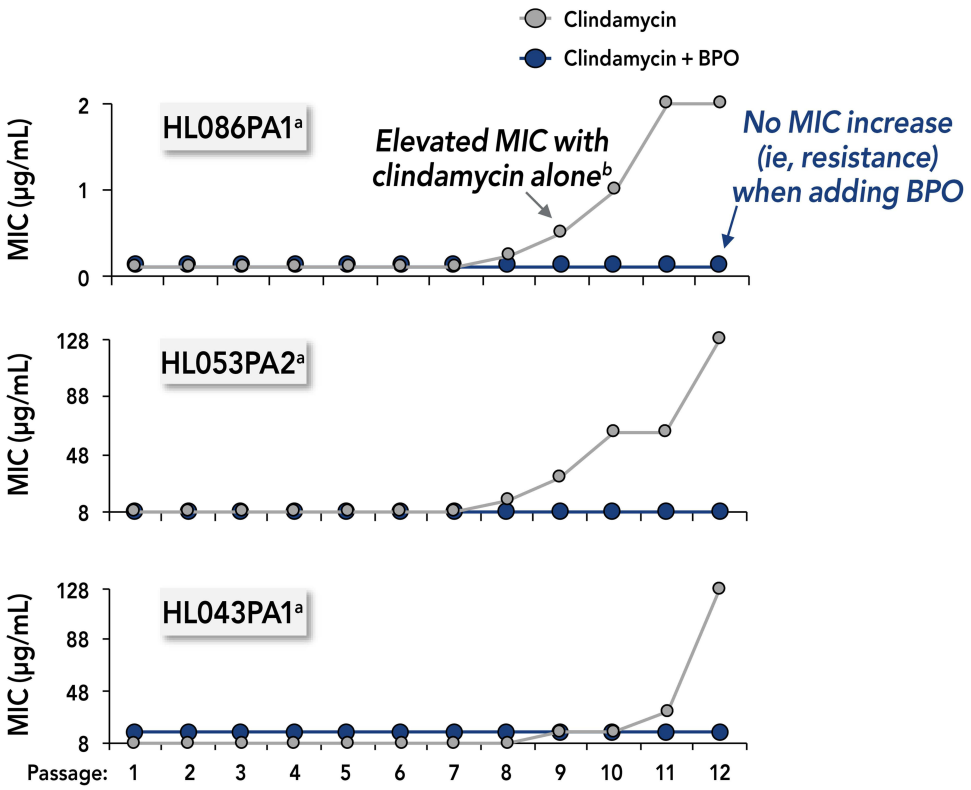

Figure 6 Development of antibiotic resistance to clindamycin compared with clindamycin/BPO. Inclusion of BPO with clindamycin prevented the development of resistance in *C. acnes* cultures repeatedly exposed to clindamycin.
Notes: [a]Representative acne-associated strains that were highly susceptible to clindamycin. [b]Meaningful increase in MIC indicated by ≥3-fold increase from the first passage.
Abbreviations: BPO, benzoyl peroxide; MIC, minimum inhibitory concentration.

while the untreated control showed a high cell density of normal, bacillus shaped cells (Figure 5A). TEM, which produces two-dimensional images of cell interiors,[35] showed profound effects of clindamycin+BPO on the morphology of *C. acnes*, including thinning, translucent cell walls with loss of integrity, decrease in the density and amount of cytoplasm, and evidence of cell leakage, while untreated control cells demonstrated intact, well-defined cell walls and plasma membranes, with a dense cytoplasm (Figure 5B).

Part 4: Preventing Antibiotic Resistance with BPO

Repeated exposure to clindamycin alone led to the development of resistance in 3 *C. acnes* strains tested, as indicated by a ≥3-fold increase in MIC over repeated passages. However, the same *C. acnes* strains had no change in MIC over repeated passages when exposed to a combination of clindamycin with BPO, suggesting the inclusion of BPO prevents the development of resistance to clindamycin (Figure 6).

Discussion

In this in vitro study, all tested antibiotics possessed generally similar activity against most *C. acnes* strains, though antibiotic susceptibility pattern was highly strain dependent. The combination of clindamycin and BPO resulted in an additive effect for over half of acne-associated strains tested. Further, formulations with BPO enhanced activity against strains less susceptible to clindamycin and prevented the development of resistance during repeated exposure to clindamycin.

MIC ranges for clindamycin and erythromycin (<0.016–>256 µg/mL, each) reported in this study are comparable with other in vitro studies (clindamycin: ≤0.125–500; erythromycin: ≤0.25–>1000).[36,37] However, a comparison of antibiotic MICs across studies is challenging as values can vary with study design, including the *C. acnes* isolates used (clinical isolates versus bacterial cultures from the American Type Culture Collection) and bacterial growing conditions

(growth media, etc.). Further, rising antibiotic resistance may be reflected in increased MIC against *C. acnes* isolates in more recent versus older studies, especially if clinical isolates are evaluated.

Some limitations of this study must be considered in the interpretation of these data. While each part of this 4-part study tested between 3 and 31 strains of *C. acnes*, many more strains, each with unique genetic elements, are associated with both healthy and acne skin.[30,38] This strain selection may limit the generalizability of these study findings. Nevertheless, the *C. acnes* strains tested in this study did encompass a variety of neutral, acne-associated, and healthy types. Other limitations are inherent to the in vitro nature of this study. While studies have repeatedly confirmed the potent bactericidal activity of BPO in vivo, its in vitro activity is seemingly less robust, as evidenced by high MIC values against *C. acnes* strains across several studies (31.25–9375 μg/mL).[36,37,39–45] Therefore, the effect of combining clindamycin with BPO may have been underestimated in this study. Additionally, many skin-related bacteria can form biofilms, rendering them resistant to antimicrobial therapies.[36,46] As such, in vitro studies are limited in their ability to assess how biofilm-forming bacteria respond to antibiotics with or without BPO.

Despite these limitations, this in vitro study's finding that the combination of BPO with clindamycin prevented the development of antibiotic resistance during repeated exposure to clindamycin is in line with clinical findings in patients with acne. In a 16-week study of patients with mild to moderate acne, counts of clindamycin-resistant *C. acnes* remained at or below baseline values with clindamycin phosphate 1%/BPO 5% gel treatment but increased to >1600% of baseline values with clindamycin 1% gel monotherapy (P=0.018 versus combination gel).[47] Similarly, a combination of BPO with the antibiotic erythromycin, but not erythromycin alone, was associated with a significant reduction from baseline in erythromycin-resistant *C. acnes* in patients with mild to moderate acne after 6 weeks of use.[48] Although the efficacy of combination therapy against resistant *C. acnes* strains may vary from one patient to the next, results from these in vitro and in vivo studies support treatment guidelines that recommend BPO be added when long-term topical antibiotic use is necessary for the treatment of acne.[3,49]

Antibiotic stewardship encourages both the judicious use of antibiotics and a focus on potential alternative, non-antibiotic treatment options when suitable.[50,51] However, antibiotics are still an important and effective treatment option for dermatologic disorders like acne. The inclusion of BPO with clindamycin prevented the development of resistance in *C. acnes* cultures repeatedly exposed to clindamycin in this study; this finding aligns with and promotes antibiotic stewardship. In fact, though acne treatment guidelines from the American Academy of Dermatology recommend against the use of antibiotics as monotherapy, fixed-dose combinations of BPO and a topical antibiotic are recommended for acne treatment.[3] While BPO and clindamycin may be prescribed as monotherapies for concomitant use by the patient, low adherence rates typical of oral or topical acne treatments may be exacerbated by complex regimens that require the layering of multiple products.[52,53] As such, the risk of antibiotic resistance may be increased due to sub-optimal patient adherence to 2 separate acne treatments.[53]

Combining treatments in an easy-to-use, fixed-dose formulation reduces treatment regimen complexity, potentially circumventing these pitfalls of combining monotherapies.[52,54] Fixed-dose dual-combination treatments approved by the US Food and Drug Administration (FDA) include clindamycin/BPO (4 products)[23,25,27,28] and erythromycin/BPO (2 products).[24,26] Notably, FDA approval of the only fixed-dose, triple-combination topical acne treatment—clindamycin phosphate 1.2%/adapalene 0.15%/BPO 3.1% gel (CAB; Cabtreo®; Ortho Dermatologics)[29]—adds to the existing armamentarium of clindamycin/BPO fixed-combination products.[55,56]

Finally, while the findings of this study have been discussed in the context of acne and its treatment, it bears noting that *C. acnes* has been implicated in other pathological states like sarcoidosis, infective endocarditis, prostate cancer, and infection involving prosthetic devices such as prosthetic joints and cardiac implantable devices.[57,58] Therefore, both the successful treatment of antibiotic-resistant *C. acnes* and the prevention of antibiotic resistance development are of concern to multiple therapeutic areas outside of acne.

Conclusion

The antibiotic compounds tested in this study possessed similar activity against most *C. acnes* strains, with formulations containing BPO having enhanced activity against strains less susceptible to clindamycin. The combination of clindamycin and BPO resulted in an additive effect for over half of the acne-associated strains tested. Further, the inclusion of

BPO with clindamycin prevented the development of resistance in *C. acnes* cultures repeatedly exposed to clindamycin. While its generalizability may be impacted by the *C. acnes* strains tested, findings from this in vitro study suggest that adding BPO to an antibiotic may improve antimicrobial activity against less susceptible *C. acnes* strains and may limit the development of resistance.

Data Sharing Statement

Available upon request.

Acknowledgments

The abstract and data presented here have previously been presented in poster form at: AAD Annual Meeting, 17–20 March 2023, New Orleans, LA, USA; Fall Clinical Dermatology Conference, 19–22 October 2023, Las Vegas, NV, USA; ODAC Dermatology, Aesthetics and Surgical Conference, 11–14 January 2024, Orlando, FL, USA; Maui Derm Caribbean, 10–13 January 2024, Palm Beach, Aruba. The abstract and poster presented at the Fall Clinical Dermatology Conference were published in the January 2024 supplement of Skin (https://skin.dermsquared.com/skin/article/view/2409).[59]

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Disclosure

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