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A Comparison of Honey and Standard Dressings on Microorganisms in Open Tibia Fractures

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Abstract

Open tibia fractures, particularly from high-energy trauma, are often infected, making treatment difficult. Honey, with its antibacterial characteristics, has been recommended as an alternative to standard wound dressings. This study compares the efficacy of honey dressings versus standard dressings in reducing microorganism presence in open tibia fractures. This a randomized, open-label, parallel-group experiment study done at the University Teaching Hospital of Kigali, Rwanda. Honey or regular saline dressings were randomly assigned to 98 Gustilo IIIA open tibia fracture patients. Days one and five wound assessments, bacterial cultures, and antibiotic sensitivities. Microorganism decrease was the main outcome, while wound size, infection rates, pain, and other wound characteristics were supplementary metrics. Statistical analysis was conducted with STATA 23 and a significance level of $p<0.05$. On Day one, there were no significant differences between the two groups in terms of microorganism presence or wound characteristics. However, by Day five, Honey dressing group showed a significant reduction in bacterial presence compared to the control group, with 82% of the honey-treated wounds showing no bacterial growth versus 62.5% in the control group. Honey dressings were particularly effective in reducing Staphylococcus aureus and Pseudomonas spp. infections. Antibiotic sensitivity patterns were similar between groups, although Honey-treated wounds exhibited slightly increased sensitivity to chloramphenicol combinations. In conclusion, Honey dressings reduced antibiotic-resistant microorganisms in open tibia fractures better than standard dressings on day five. These data suggest that Honey may be a feasible alternative to traditional wound care for open fractures, especially in resource-limited settings. These findings should be confirmed by larger sample sizes and longer follow-ups.

Keywords: *Honey Dressing, Microorganism, Open tibia fractures Gustilo IIIA, Standard Dressing.*

Introduction

Open fractures are defined as a skin discontinuity that communicates with the bone and breaches the surrounding tissues. High-energy trauma like falls from heights or car collisions can split lengthy bones open. Kakar and Tornetta (2007) relate them to severe soft-tissue injuries and wound infection. Prognosis depends on fracture displacement, comminution, and soft-tissue injury [1]. Gustilo

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& Anderson (2002) classify open fractures as Type I, II, or III (IIIA, IIIB, or IIIC) based on energy causing the injury, soft tissue damage and infection rate [2].

Immediately debridement and irrigation, antibiotics, fracture stabilization, and delayed wound closure were recommended. Depending on contamination, 2-25% of open fractures result in infection, one of the most serious consequences. Each treating centre uses different therapeutic drugs to treat open fracture wounds, and Staphylococcus Aureus is the most prevalent germ [3].

Gram-positive to gram-negative microbial flora in open fractures is increasing surgical site infection, according to recent studies. One study reported 43.9% infection in open fractures. Most early wound cultures yielded Gram-negative organisms (76%), mostly Pseudomonas (36%) and Acinetobacter (20.7%). Gram-positive organisms caused most infections after 2 weeks. Staphylococcus aureus (93.5%) dominated Gram-positive bacteria [4].

Systemic antibiotics are the main infection prophylaxis in open fractures. Antibiotic administration, culture, and sensitivity reduce surgical site infection in wounds debrided within 24 hours [5]. Many studies advocate using antibiotics based on a direct postoperative wound sample, culture, and sensitivity at the initial dressing. In open fractures, antibiotics must be restricted within 72 hours and wound care provided [6]. Normal saline compresses, silver sulfadiazine, betadine, paraffin dressings, hydrogel, honey, and olive oil are wound treatments [7].

Honey has been used for centuries to treat many ailments. Since 2500 BC, Ayurvedic Medicine and other ancient societies employed it. Honey has traditionally been used to suppress microorganisms and heal wounds. Honey's popularity returned due to antibiotic-resistant bacteria, and it immediately became popular in wound treatment and regenerative medicine [8]. Clinical, laboratory, and animal investigations show that honey with the above bioactivities can be utilized on open wounds. Hadda Laallama et al. tested 13 Algeria desert Saharan honey kinds for antibacterial activity against bacterial pathogens, floral sources, and physicochemical properties. Certain botanical Saharan honey has physicochemical and pollinic properties with antibacterial potential, according to this study. This promotes in vivo and in vitro honey characterisation [9].

In Indonesia, Deviandri R. et al. reported that honey dressing in infected open fractures reduced bacteria load more than normal saline [10]. In their analysis of several clinical trials, including animal models and laboratory research, Molan (2006) found honey's antibacterial capabilities useful to wound care [11]. The literature has indicated that Honey is better than most local dressings for burns, diabetic foot wounds, and normal saline impregned dressing [12]. Honey reduces hospital stay and bacterial load in surgical wounds and infected open fractures, as well as burns [10]. Honey is effective in wound treatment; however, few studies have used it to treat open fractures.

This study has compared the effect of honey and the standard dressings on microorganism in open fractures in surgically treated patients at the University Teaching Hospital of Kigali.

Methods

Study Design and Setting

This open-label, randomized, comparative, parallel-group trial, conducted at the University Teaching Hospital of Kigali (CHUK), Rwanda, which serves over 8 million people.

Population and Sampling

Patients with open fractures of long bones classified as Gustilo IIIA, admitted to the Orthopaedic and Trauma wards at CHUK from August 2022 to June 2023, were included. Key inclusion criteria were patients aged 18 years and above with non-infected open fractures at admission. Exclusion criteria included comatose or mentally disabled patients, those consuming steroids or undergoing chemotherapy, and patients with a history of keloid formation, drug and alcohol abuse, heavy smoking, or uncontrolled glycemia in diabetic patients. The calculated sample size was 98 participants, accounting for potential non-responses, with 50 assigned to the intervention group (Honey) and 48 to the control group (Conventional).

Interventions

Participants received either standard saline dressings (control) or honey dressings (intervention) using Uburanga honey from Rwanda. Wounds were cleansed with saline, treated with the respective dressing, and wrapped with sterile gauze. The primary outcome measure for this study was the decrease of microorganism in both groups at five days of wound swab. Secondary outcome measures were wound size, infection, pain level, itchiness, odor, exudate, cleanliness at day five post operative.

Procedures

From 612 assessed patients with open tibia fractures, 514 were eliminated, leaving 98 meeting the trial criteria to be randomised into two groups where 48 got standard saline dressing (control group) and 50 received honey dressing. The year-long CHUK Orthopaedic unit research observed open tibia fracture patients daily for 30 days, assessing wound status, bacterial culture and sensitivity. Uburanga honey from Rwanda's Akagera Park Forest was used and kept at ambient temperatures in the hospital pharmacy in sterile 50 mg flacons branded by the Rwanda Standard Board. The trial was well-designed, with no loss to follow-up, and nurses handled honey without refrigeration.

Data Management and Analysis

Data was managed using the Kobo Toolbox platform, ensuring confidentiality and compliance with data protection regulations. Data was analysed using STATA 23 software, with categorical variables expressed as proportions and continuous variables as means and standard deviations. We have conducted a logistic regression model for association between the dependant and independent variables. Bayesian methods and chi-square tests were used, with significance defined as a p-value less than 0.05.

Ethical Considerations

Ethical approval was obtained from the Rwanda National Ethics Committee (No.34/RNEC/2022) and the University Teaching Hospital of Kigali Joint Institutional Ethics Review Committee (EC/CHUK/081/2021). The trial was registered with the Rwanda Food and Drug Administration (No. 017/CTAC/FDA/2022). Informed consent was obtained from all participants before enrolment into the study, with data kept confidential and used solely for research purposes. Participants were informed of their right to voluntarily discontinue participation at any time, although no patient did so during the study.

Results

Demographics

A comparison of demographics between control (N=48) and intervention (N=50) To ensure comparability between the control (N=48) and intervention (N=50) groups, demographic and socioeconomic factors were used to compare honey and conventional dressings on bacteria in open fractures. Control group contained 27.27% more adults over 45 than intervention group (16%), however this difference was not significant (p=0.406). Both groups had more men (79.17% in the control and 94% in the intervention), but the difference was not significant (p=0.30). Rural and urban residence status distributions were similar between groups (p=0.830), suggesting a balanced representation of participants from different living situations. None of the control group had a university degree, whereas 8% of the intervention group did (p=0.168).

Mostly farmers or private/business workers, occupation did not differ (p=0.437). These groups have similar economic status (p=0.193), with majority in category II. Road traffic injuries (65% in both groups) did not differ significantly (p=0.566), showing that it was not a confounding variable. Honey and traditional dressings for open fracture bacteria were fairly compared in this study since the control and intervention groups were well-matched (Table 1).

Table 1. Demographics

Factors	**Control N:48**		**Intervention N:50**		**Test-**	
	N	**%**	**N**	**%**	**X^2**	**(p-value)**
Age group Mean:36.37±14.42					1.8022	0.406
18-30	18	37.50	21	42.00		
31-45	17	35.42	21	42.00		
>45	13	27.27 .08	8	16.00		
Sex					4.6833	0.30
Female	10	20.83	3	6.00		
Male	38	79.17	47	94.00		
Residence					0.0462	0.830
Rural	22	45.83	24	48.00		
Urban	26	54.17	26	52.00		
Education level					5.050	0.168
None	11	22.92	7	14.00		
Primary	28	58.33	28	56.00		
Secondary	9	18.75	11	22.00		
University	0	0.00	4	8.00		
Occupation					3.7753	0.437
Farmer	23	47.92	20	40.00		
Others	2	4.17	6	12.00		
Private/Business	20	41.67	18	36.00		
Public officers	0	0.00	1	2.00		
Students	3	6.25	5	10.00		
Economic Status					3.2939	0.193
I	3	6.25	9	18.00		
II	26	54.17	22	44.00		
III	19	39.58	19	38.00		
Cause of Injury					3.888	0.566

Road Traffic Injury	31	64.59	33	66.00		
Fall	13	27.08	10	20.00		
Others (mining, physical assault)	4	8.33	7	14.00		

Clinical Factors at Admission

Table 2 shows honey and standard dressings for open fractures were comparable in terms of comorbidities, previous injuries, emergency immobilization, wound washout, tetanus prevention, antibiotic administration, associated injuries, and side and site of injury. Both groups got antibiotics at comparable times and types, with most getting combinations. The control group had more comminuted fractures (66.67%) than the intervention group (46.00%), but the intervention group had more uncomplicated fractures (54.00% vs. 33.33%, p=0.039). Despite identical clinical characteristics, fracture type may affect dressing efficacy.

Table 2. Clinical Factors at Admission

Factors	**Control (N:48)**		**Intervention(N:50)**		**Test**	
	N	**%**	**N**	**%**	X^2	**(p-value)**
Comorbidities (HIV,DM,Hepatitis)					5.3392	0.376
Yes	4	8.34	4	8.34		
Non	44	91.67	46	92.00		
Previous same limb injury					2.3602	0.124
No	42	87.50	48	96.00		
Yes	6	12.50	2	4.00		
Immobilisation at the emergency					0.009	0.977
No	1	2.08	1	2.00		
Yes	47	97.92	49	98.00		
Wound wash out at the emergency					2.0288	0.154
No	4	8.33	1	2.00		
Yes	44	91.67	49	98.00		
Tetanus prevention						
No	8	16.67	2	4.00		
Yes	40	83.33	48	96		
Antibiotics at the emergency					0.0009	0.977
No	1	2.08	1	2.00		
Yes	47	97.97	49	98.00		
Time of the 1st ATB from arrival					1.1025	0.294

>6Hours	18	37.50	24	48.00		
≤6Hours	30	62.50	26	52.00		
Type of ATB at Emergency					6.4066	0.269
Single ATBs	19	39.58	22	44.00		
Combined ATBs (	29	60.42	27	54.00		
None	0	0.00	1	2.00		
Associated injury					0.4788	0.489
Head injury	7	14.58	5	10.00		
None	41	85.42	45	90.00		
Side of injury					3.7126	0.156
Bilateral	3	6.25	1	2.00		
Left	22	45.83	32	64.00		
Right	23	47.92	17	34.00		
Site of injury						
Lower 1/3	23	47.92	23	46.00		
Middle 1/3	20	41.67	22	44.00		
Upper 1/3	5	10.42		10.00		
Type of the fracture					4.2476	0.039
Communited	32	66.67	23	46.00		
Simple	16	33.33	27	54.00		

*Single: Cefazolin, Cefotaxime, Ceftriaxone

*Combined ATBs: Cefotaxime & Gentamycin, Ceftriaxone & Gentamycin

Perioperative Information

The perioperative comparison of honey and conventional dressings in open fractures showed some differences. The intervention group utilised spinal anaesthesia 100% of the time, while the control group used general anaesthesia only 8.33% of the time (X^2=4.3440, p=0.037). Significant differences in bone coverage were seen, with primary closure reached in 97.92% of the control group and 86.00% of the intervention group (X^2=4.6389, p=0.031). Factors affecting outcomes include procedure type (splint: 10.42% control, 8.00% intervention; external fixator: 68.75% control, 80.00% intervention), antibiotic prophylaxis (Cefazolin: 8.33% control, 10.00% intervention; Ceftriaxone: 81.25% control, 78.00% intervention), irrigation volume (<9 litters: 89.13% control, 93.88% intervention), estimated blood loss (≤100 ml: 89.58% control, 96.00% intervention), perioperative transfusions (8.33% control (Table 3).

Table 3. Perioperative Information of the Patients

Factors	**Control N:48**		**Intervention N:50**		**Test-**	
	N	**%**	**N**	**%**	**X^2**	**(p-value)**
Type of anesthesia					4.3440	0.037
GA	4	8.33	0	0.00		
SA	44	91.67	50	100.00		

Types of procedure					1.7423	0.418
Splint	5	10.42	4	8.00		
External fixator	33	68.75	40	80.00		
Internal fixator (IMN)						
ATBs Prophylaxis					3.0716	0.381
Cefazolin	4	8.33	5	10.00		
Cefotaxime	2	4.17	0	0.00		
Ceftriaxone	39	81.25	39	78.00		
Other	3	6.25	6	12.00		
Irrigation (L of NS)					0.6933	0.405
<9	41	89.13	46	93.88		
≥ 9	5	10.87	3	6.12		
Estimated blood loss					1.5203	0.218
≤ 100	43	89.58	48	96.00		
≥ 100	5	10.42	2	4.00		
Bone Coverage					4.6389	0.031
Primary closure	47	97.92	43	86.00		
Not covered	1	2.08	7	14.00		
Per operative transfusion					0.0816	0.775
No	44	91.67	45	90.00		
Yes	4	8.333	5	10.00		
Post-op ATBs					10.10	0.183
Single ATBs	4	14.58	6	12.00		
Combined ATBs	44	83.14	33	66.00		
None	0	0.00	1	2.00		

*Single ATBs: Cefazolin, Ceftriaxone

*Combined ATBs: Cefazolin &Gentamycin, Cefotaxime&Gentamycine, Ceftriaxone&Gentamycine

Wound Assessment on Day One Post Operative

Honey and conventional dressings on bacteria in open fractures were equivalent on D1 wound evaluation. While slight discomfort was reported by 45.83% of the control group and 46.00% of the intervention group, there was no significant difference (p=0.639, X^2=0.8952). No significant difference in itchiness was observed across groups (p=0.430, X^2=2.7603). Odor levels were similar, with 93.75% of the control group and 90.00% of the intervention group reporting no odor (p=0.514, X^2=2.2935). Exudate types were not significantly different (p=0.705, X^2=1.4015), with 83.33% of the control group and 86.00% of the intervention group reporting no exudate. Both groups showed great cleanliness, with no significant difference (p=0.654, X^2=1.6254): 91.67% of the control group and 84.00% of the intervention group were clean. Similarly, wound surface areas showed no significant difference (p=0.649, X^2=0.2070). Significant difference in wound depth was seen between the intervention group (20.00%) and the control group (4.17%), with a p-value of 0.017 and X^2=5.7135. Honey dressings perform similarly to normal dressings in most perioperative outcomes, except wound depth (Figure 2).

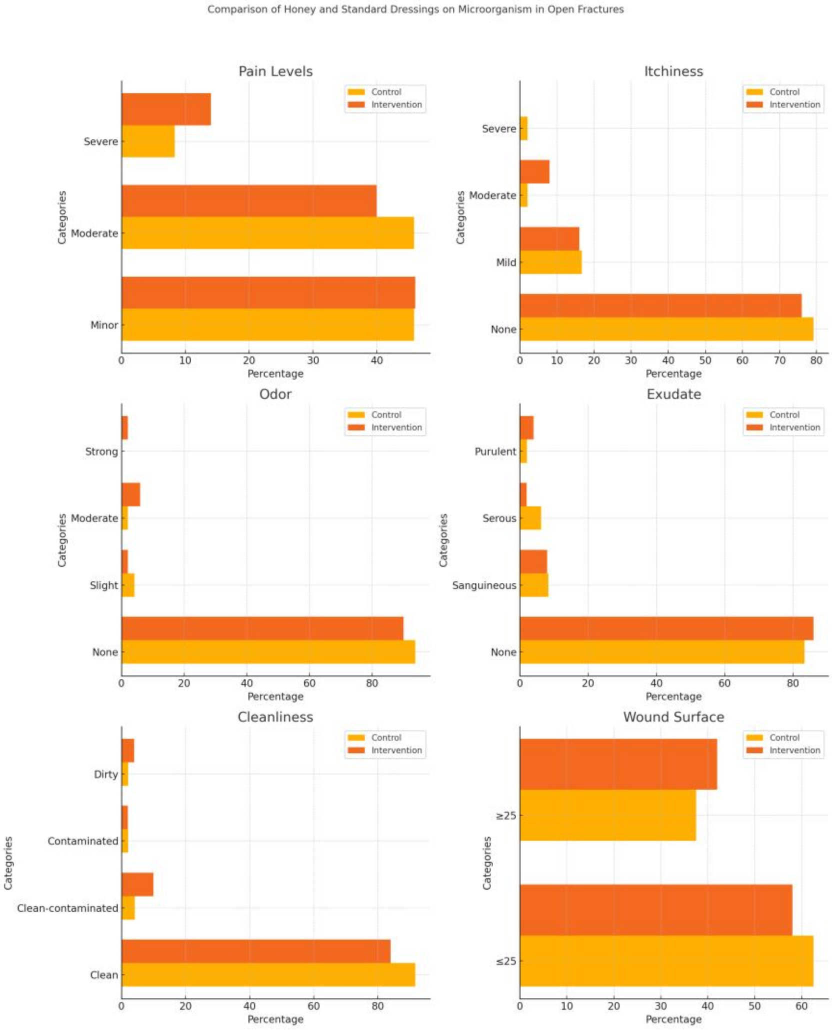

Figure 1. Wound Assessment on Day One of Dressing Post Operative.

Microorganism Identification Day One of Dressing

The study found no significant differences in microbe identification between the control group and the honey dressing group on the first day of dressing. Both groups had 8.33% Acinetobacter spp., 6.25% Enterobacter spp., 4.17% Escherichia coli, 2.08% Gram-positive bacilli, 4.00% Klebsiella spp., 4.17% Pseudomonas spp., and 4.00% Staphylococcus aureus. All microorganisms had p-values of 0.696, showing no statistically significant differences between the groups. This suggests that on day one of dressing, before applying honey, the microbial profiles of honey dressings were like those of regular dressings (Figure 2).

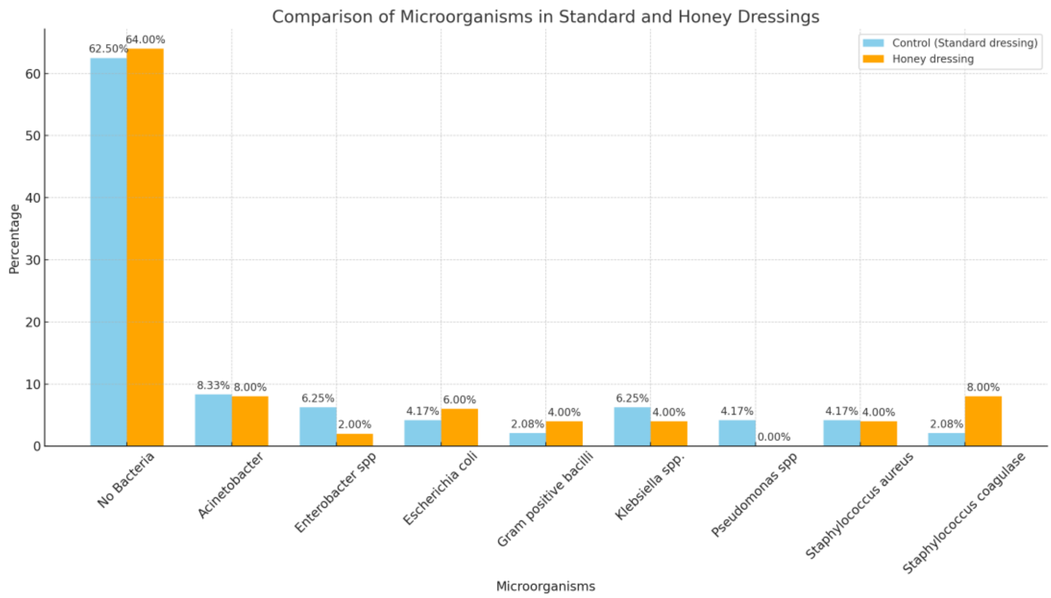

Figure 2. Microorganism Identification Day One of Dressing (Post Operative).

Honey vs Standard Dressings ATBs Sensitivity Day One Post Operative

The analysis of antibiotic sensitivity on day one found no significant difference between standard and honey dressing (X^2 = 18.8627, p-value = 0.466). The two groups have comparable sensitivity patterns with minimal differences. The control group is more sensitive to Gentamicin and Ciprofloxacin combinations (4.17% vs. 0.00%), while the honey dressing group is more sensitive to Chloramphenicol combinations (4.00% vs. 2.08%). Honey dressing also had more antibiotic-free instances (74.00% vs. 66.67%). Despite modest changes in antibiotic responses, honey and conventional dressings affect antibiotic sensitivity similarly (Table 4).

Table 4. Honey vs Standard Dressings ATBs Sensitivity Day One Post Operative

Factors	**Control (N:48)**		**Honey dressing (N:50)**		**Test-**	
	N	**%**	**N**	**%**	**X^2**	**(p-value)**
ATBs Sensitivity					18.8627	0.466
Amikacillin combinations	4	8.33	3	6.00		
Ceftriaxone Combinations	1	2.08	1	2.00		
Chloramphenicol Combinations	1	2.08	2	4.00		
Gentamicin Combinations	2	4.17	0	0.00		
Imipenem Combinations	3	6.25	3	6.00		
Vancomycin Combinations	2	6.25	3	6.00		
Ciprofloxacin Combinations	3	4.17	0	0.00		
Other Single Antibiotics	3	6.25	2	4.00		
N/A	32	66.67	37	74.00		

Sensible Antibiotics (ATBs)

1. Amikacillin Combinations: Amikacillin alone,Amikacillin & Ampicillin,Amikacillin & Ciprofloxacin,Amikacillin & Imipenem
2. Ceftriaxone Combinations: Ceftriaxone & Chloramphenicol
3. Chloramphenicol Combinations:Chloramphenicol & Imipenem,Pefloxacin & Chloramphenicol,Vancomycin & Chloramphenicol
4. Gentamicin Combinations: Gentamicin & Piperacillin,Gentamicin & Vancomycin
5. Imipenem Combinations: Imipenem alone,Amikacillin & Imipenem,Chloramphenicol & Imipenem,Pefloxacin & Imipenem
6. Vancomycin Combinations: Vancomycin alone,Vancomycin & Chloramphenicol,Vancomycin & Clindamycin,Vancomycin, Clindamycin & another component
7. Profloxacin Combinations: Pefloxacin & Chloramphenicol,Profloxacin & Imipenem
8. Other Single Antibiotics: Polymyxin B alone
9. No Antibiotics (N/A): This category is crucial as it covers cases where no antibiotics sensitivity found.

Honey vs Standard Dressings ATBs Resistance on Day One

The table 5 compares antibiotic resistance in control (N=48) and honey dressing (N=50) groups for open fracture microorganism treatment. No germs were isolated, hence 66.67% of control group participants and 74.00% of honey dressing group participants had no antibiogram. Resistance to certain antibiotic combinations was modest and widespread, with no notable differences between groups. Amoxicillin Clavulanate resistance was 0.00% in the control group and 2.00% in the honey group, while Gentamicin Combinations resistance was 4.17% and 8.00%. Piperacillin Tazobactam and Tetracycline & Clindamycin revealed minimal resistance differences. The $\mathbf{X^2}$ of 27.33 with a p-value of 0.500 shows no significant difference in antibiotic resistance patterns between the control and honey dressing groups at day one.

Table 5. Honey vs Standard Dressings ATBs Resistance on Day One of Dressing

Factors	**Control (N:48)**		**Honey dressing N:50**		**Test**	
	N	**%**	**N**	**%**	$\mathbf{X^2}$	**(p-value)**
ATBs Resistance					27.3329	0.500
Amoxicillin Clavulanate	0	0.00	1	2.00		
Ceftriaxone Combinations	3	6.25	4	8.00		
Gentamicin Combinations	2	4.17	4	8.00		
Piperacillin Tazobactam Combinations	3	6.25	1	2.00		
Tetracycline &Clindamycin Combinations	4	8.33	0	0.00		
Cefuroxime &Penicillin Combinations	1	2.08	1	2.00		
Clindamycin &Penicillin Combinations	0	0.00	1	2.00		

Cotrimoxazole&Cefotaxime Combinations	1	2.08	0	0.00		
Penicillin G &Imipenem Combinations	1	2.08	0	0.00		
Vancomycin&Tetracycline Combinations	0	0.00	1	2.00		
No Antibiogram (No germ isolated)	32	66.67	37	74.00		

ATBs Resistance

1. Amoxicillin Clavulanate
2. Ceftriaxone Combinations: Ceftriaxone & Cefotaxime,Ceftriaxone & Cefuroxime, Ceftriaxone & Ciprofloxacin, Ceftriaxone & Cotrimoxazole,Ceftriaxone & Gentamicin
3. Gentamicin Combinations: Gentamicin & Amikacin, Gentamicin & Ciprofloxacin, Gentamicin & Penicillin, Gentamicin & Piperacillin
4. Piperacillin&Tazobactam Combinations
5. Tetracycline&Clindamycin Combinations
6. Cefuroxime&Penicillin Combinations
7. Clindamycin&Penicillin Combinations
8. Cotrimoxazole&Cefotaxime Combinations
9. Penicillin G &Imipenem Combinations
10. Vancomycin&Tetracycline Combinations

Honey vs Standard Dressings Microorganism on Day Five Post Operative

Microorganism prevalence in open fracture control (standard dressing) and honey dressing groups is shown in the table5. Bacteria were absent in 62.50% of the control group and 82.00% of the honey dressing group, totalling 72.45%. Pseudomonas spp (9.41%) and Staphylococcus aureus (8.33%) were the most prevalent bacteria in the control group, while Proteus spp and Escherichia coli both occurred in 4.00% of honey dressing cases. Both groups had low rates of Acinetobacter, Klebsiella spp., and Gram-positive bacilli. The X^2= 19.3095, p-value = 0.153 shows no significant difference in microbe species between the control and honey dressing groups (Table 6).

Table 6. Honey vs Standard Dressings Microorganism on Day Five Post Operative

Factors	**Standard dressing (N:48)**		**Honey dressing (N:50)**		**Test-**	
	N	**%**	**N**	**%**	**X^2**	**(p-value)**
Type of microorganism					19.3095	0.153
No Bacteria	30	62.50	41	82.00		
Acinetobacter	3	6.25	1	2.00		
Proteus spp	1	2.08	2	4.00		
Escherichia coli	0	0.00	2	4.00		
Gram positive bacilli	1	2.08	0	0.00		
Klebsiella spp.	2	2.08	2	2.08		
Pseudomonas spp	5	9.41	0	0.00		
Staphylococcus aureus	4	8.33	1	2.00		
Stapylococous coagulase	1	2.08	0	0.00		

Honey vs Standard Dressings on Day Five ATBs Sensitivity

The study of antibiotic sensitivity on Day Five for microorganisms treated with either standard dressing or honey dressing indicates that there is no statistically significant difference between the two groups, X^2 = 18.8627, p-value = 0.466). The proportion of patients exhibiting no bacterial sensitivity is somewhat greater in the honey dressing group (74.00%) as compared to the control group (66.67%). The sensitivity to specific antibiotic combinations is generally similar, with slight differences: the control group exhibits greater sensitivity to Gentamicin (4.17% vs. 0.00%) and Ciprofloxacin (4.17% vs. 0.00%), while the honey dressing group demonstrates higher sensitivity to Chloramphenicol combinations (4.00% vs. 2.08%). The results indicate that both honey and conventional dressings had a comparable effect on the susceptibility of the bacteria to antibiotics, despite some slight variations in the particular reactions to antibiotics (Table 7).

Table 7. Honey vs Standard Dressings on Day Five ATBs Sensitivity

Factors	**Standard dressing N:48**		**Honey dressing N:50**		**Total (Factors)**		**Test-**	
	N	**%**	**N**	**%**	**N**	**%**	**X^2**	**(p-value)**
ATBs Sensitivity							18.8627	0.466
Amikacillin combinations	4	8.33	3	6.00	7	7.14		
Ceftriaxone Combinations	1	2.08	1	2.00	2	2.04		
Chloramphenicol Combinations	1	2.08	2	4.00	3	3.06		
Gentamicin Combinations	2	4.17	0	0.00	2	2.04		
Imipenem Combinations	3	6.25	3	6.00	6	6.12		
Vancomycin Combinations	2	6.25	3	6.00	65	6.12		
Ciprofloxacin Combinations	3	4.17	0	0.00	2	2.04		
Other Single Antibiotics	3	6.25	2	4.00	5	5.10		
N/A	32	66.67	37	74.00	69	70.41		

Honey vs Standard Dressings ATBs Resistance on Day Five Post Operative

The comparison of antibiotic resistance profiles on day five between standard dressing and honey dressing reveals no statistically significant difference (X^2 = 27.33, p-value = 0.500). Both dressing types show similar resistance patterns, with slight variations: higher resistance to Gentamicin (8.00% vs. 4.17%) and Ceftriaxone combinations (8.00% vs. 6.25%) in the honey dressing group, and higher resistance to Tetracycline & Clindamycin combinations (8.33% vs. 0.00%) in the control group. Additionally, the honey dressing group had a higher percentage of cases with no germs isolated (74.00% vs. 66.67%). These findings suggest that both honey and standard dressings have a comparable impact on antibiotic resistance, despite minor differences in specific antibiotic responses (Table 8).

Table 8. Honey vs Standard Dressings ATBs Resistance on Day Five Post Operative

Factors	**Standard dressing (N:48)**		**Honey dressing (N:50)**		**Test**	
	N	**%**	**N**	**%**	**X^2**	**(p-value)**
ATBs Resistance					27.33	0.500
Amoxicillin Clavulanate	0	0.00	1	2.00		
Ceftriaxone Combinations	3	6.25	4	8.00		
Gentamicin Combinations	2	4.17	4	8.00		
Piperacillin Tazobactam Combinations	3	6.25	1	2.00		
Tetracycline &Clindamycin Combinations	4	8.33	0	0.00		
Cefuroxime &Penicillin Combinations	1	2.08	1	2.00		
Clindamycin &Penicillin Combinations	0	0.00	1	2.00		
Cotrimoxazole&Cefotaxime Combinations	1	2.08	0	0.00		
Penicillin G &Imipenem Combinations	1	2.08	0	0.00		
Vancomycin&Tetracycline Combinations	0	0.00	1	2.00		
No Antibiogram (No germ isolated)	32	66.67	37	74.00		

Honey vs Standard Dressings Wound Assessment on Day Five Post Operative

On day five, wound assessment comparing standard and honey dressing showed no significant differences in pain, itchiness, odor, exudate, cleanliness, and wound surface area (X^2= 0.8952, p-value = 0.639, X^2 = 2.7603, p-value = 0.430, X^2= 2.2935, p-value = 0.514, X^2= 1.4015, p-value = 0.705, X^2= 1.6254, p-value = 0.654). Significant difference in wound depth: conventional dressing group had a larger percentage of deep wounds (20.00% vs. 4.17%, X^2 = 5.7135), p-value = 0.017). While most wound evaluation criteria are similar between the two dressing methods, conventional dressing is linked with more deep wounds (Table 9).

Table 9. Honey vs Standard Dressings Wound Assessment on Day Five.

Factors	**Standard dressing (N:48)**		**Honey dressing (N:50)**		**Test-**	
	N	**%**	**N**	**%**	**X^2**	**(p-value)**
Pain level					0.8952	0.639
Minor	22	45.83	23	46.00		
Moderate	22	45.83	20	40.00		

Severe	4	8.33	7	14.00		
Itchiness					2.7603	0.430
None	38	79.17	38	76.00		
Mild	8	16.67	8	16.00		
Moderate	1	2.08	4	8.00		
Severe	1	2.08	0	0.00		
Odor					2.2935	0.514
None	45	93.75	45	90.00		
Slight	2	4.17	1	2.00		
Moderate	1	2.08	3	6.00		
Strong	0	0.00	1	2.00		
Exudate					1.4015	0.705
None	40	83.33	43	86.00		
Sanguineous	4	8.33	4	8.00		
Serous	3	6.25	1	2.00		
Purulent	1	2.08	2	4.00		
Cleanliness					1.6254	0.654
Clean	44	91.67	42	84.00		
Clean-contaminated	2	4.17	5	10.00		
Contaminated	1	2.08	1	2.00		
Dirty	1	2.08	2	4.00		
Wound |surface	Mean=2.73. Max=12 Min=1				0.2070	0.649
≤25	30	62.50	29	58.00		
≥25	18	37.50	21	42.00		
Wound depth					5.7135	0.017
Deep (exposed bone)	10	20.00	2	4.17		
Full (covered by muscles	40	80.00	46	95.83		

Microorganism Comparison Day One and Day Five Post Operative

Comparison of Microorganism Identification on day one and day five post operative.

In comparing specific bacteria trends between the control and honey dressing groups from day one to day five, the control group showed a constant 62.5% "No Bacteria," while the honey group increased from 64% to 82%. Acinetobacter decreased from 8.33% to 6.25% in the control group and from 8.33% to 2% in the honey group. Enterobacter spp was present on Day 1 (6.25% control, 2% honey) but absent on Day 5. Escherichia coli decreased from 4.17% to 0% in the control group and from 6% to 4% in the honey group. Gram Positive Bacilli remained at 2.08% in the control group but dropped from 4% to 0% in the honey group. Klebsiella spp decreased from 6.25% to 4.08% in the control group and remained stable (4% Day 1, 2.08% Day 5) in the honey group. Pseudomonas spp increased from 4.17% to 9.41% in the control group, while staying at 0% in the honey group. Staphylococcus aureus rose from 4.17% to 8.33% in the control group and decreased from 4% to 2% in the honey group. Staphylococcus coagulase stayed at 2.08% in the control group but fell from 8% to 0% in the honey group. These trends indicate that honey dressings are more effective in reducing several specific bacteria compared to standard dressings (Figure3).

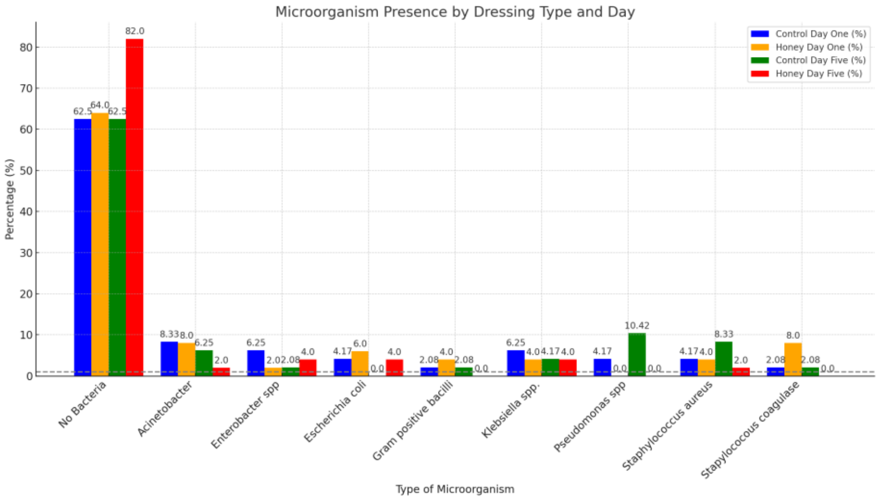

Figure 3. Microorganism Comparison Day One and Day Five Post Operative

Logistics Regression Factors Influencing the Rate of Microorganism at Day Five Post Operative

The figure 4 shows logistic regression coefficients for parameters affecting microorganism rate on day 5 (D5). Notably, persons aged 31-45 and above 45 had considerably greater microorganism rates than younger age groups, with coefficients of 0.789 and 1.045, respectively, with confidence intervals excluding zero. A statistically significant coefficient of -0.654 shows that men have a lower rate than females. Rural residency and emergency antibiotics administration indicate non-significant trends toward higher and lower rates, respectively. Unwashed wounds in the emergency increase microbe rates (coefficient 1.267), as do middle tibia injuries (coefficient 0.785). This research shows how demographics and treatment affect day five post operative microbial infection rates.

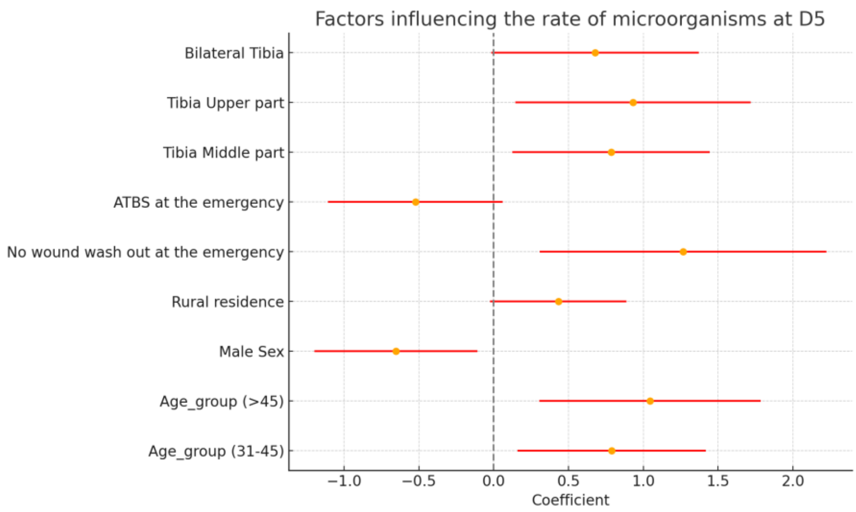

Figure 4. Logistics Regression Factors Influencing the Rate of Microorganism at Day Five Post Operative.

Logistics Regression Factors Influencing the ATBS Sensitivity at Day Five Post Operative

Antibiotic sensitivity at day five post operative is not significantly affected by major variables, including age, sex, residence, and surgery type, according to logistic regression analysis. Patients with greater education levels may have somewhat higher probabilities of altered antibiotic sensitivity at day five post operative. Many factors have 0% confidence intervals, indicating little evidence for their impacts. The data did not support the prediction that economic status or dressing type significantly affect antibiotic sensitivity at Day 5 of dressing (Figure5).

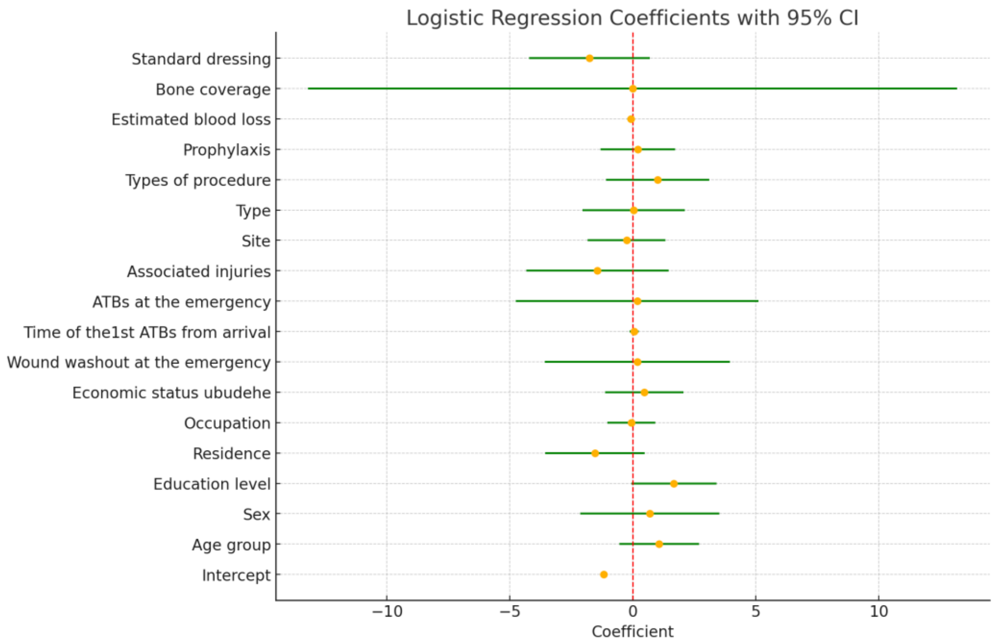

Figure 5. Factors Influencing the ATBS Sensitivity at Day Five Post Operative.

Discussion

We compared honey and standard dressings for managing microorganisms in open tibia fractures found that the two groups were well-matched in demographic and socioeconomic factors. The control group had a higher proportion of participants over 45 years, but this difference was not statistically significant. This aligns with other wound care studies' importance of demographic matching. Due to comorbidities and lowered cellular activity, older people often heal wounds more slowly, making age a crucial factor in wound healing [13].Gender distribution was mostly male in both groups, and this shows the population most at risk for open tibia fractures, especially in rural and low-income areas with high-risk jobs [14]. Since gender did not hamper the results, the study's comparability is strengthened by the non-significant gender distribution difference.

The study found no significant differences in rural versus urban residence status, indicating equal distribution of environmental factors like healthcare access, which is crucial for rural populations to overcome challenges in wound care. The similarity in residence status across the groups suggests that the findings could be applicable to diverse settings, consistent with previous research that controlled for such variables. The two groups had similar education levels. This matters because health literacy, frequently connected to education, affects wound care results. Occupational status, mostly farmers or private/business workers, did not differ between groups. Manual labourers are more likely to get complicated, polluted wounds, which can lead to infection [15].

Perioperative comparisons showed discrepancies that may affect dressing efficacy. On the first day, the assessment of the wound revealed no notable disparities in pain, itching, odor, exudate, and cleanliness between honey and normal dressings. According to microbiological evaluations, on the first day, the bacterial profiles of both dressings were comparable, showing no appreciable variations in the frequency of pathogens such Acinetobacter, Escherichia coli, and Staphylococcus aureus. These findings are almost the same in other studies on open fractures [16].

By day five, however, the honey dressings seemed to be working better than the regular dressings in killing some germs, such as Pseudomonas spp. and Staphylococcus coagulase. Honey's antibacterial qualities, especially its capacity to suppress a wide range of microorganisms, have been extensively studied in the scientific literature. Honey's efficacy in reducing bacterial load in wounds is thought to be due to its high osmolarity, low pH, and the presence of hydrogen peroxide and other antimicrobial compounds [17].

Antibiotic sensitivity pattern analysis revealed no statistically significant differences across the groups, suggesting that regular dressings and honey had comparable impacts on bacterial resistance. The honey group had increased sensitivity to combinations of chloramphenicol, while the control group exhibited somewhat higher sensitivity to combinations of gentamicin and Ciprofloxacin. These minute variations align with research demonstrating that honey might increase bacterial susceptibility to certain medicines, perhaps because it can break down bacterial biofilms, which are known to shield bacteria from antibiotics[18].

Comparing the Microorganism trends in both groups from day 1 and day 5, honey dressings reduce bacteria better than normal dressings, as shown by higher "No Bacteria" rates and substantial decreases in Acinetobacter, Staphylococcus aureus, and Pseudomonas. Honey has antibacterial capabilities due to its low pH and high osmolarity [19]. Despite its growth in the control group, Pseudomonas spp. was absent in the honey group, demonstrating honey's ability to fight antibiotic-resistant infections. Honey is an effective wound treatment option, according to our findings research. According to the logistic regression analysis, men exhibit lower rates of microorganisms than women on day 5, while older age groups (31-45 and above 45) had considerably greater rates. Unwashed wounds and injuries to the middle tibia are linked to higher rates of microbial infection; however, non-significant patterns are seen in rural residence and emergency antibiotic usage. These findings confirm previous research on the effects of therapy and demographic factors on infection rates following open tibia fractures [20].

This trial supports the literature that honey dressings can manage bacteria in open fractures better than regular dressings. Honey's wound care efficacy is supported by the study's rigorous demographic and socioeconomic matching. Honey dressings may reduce deep wound infections and bacterial multiplication, as shown by wound depth and bacterial reduction differences. These findings reinforce the growing body of research supporting honey as a supplemental or alternative wound therapy.

This work offers fresh insights into alternative wound care in resource-constrained situations by introducing the novel use of honey as a natural remedy for treating microbes in open fractures. The results are more credible because of the well-matched research groups, strict data management, and randomized design. The study's limitations, which might have an impact on the findings' generalisability and repeatability, include its small sample size and single-centre design. Long-term consequences could also not be captured by the little follow-up time, and observational biases might still exist.

Conclusion

This study demonstrates that honey dressings are superior to standard saline dressings in reducing bacterial presence, particularly antibiotic-resistant strains like Staphylococcus aureus and Pseudomonas spp., in open tibia fractures. By day five, honey-treated wounds showed a significantly higher rate of bacterial clearance compared to the control group. These findings support honey as a cost-effective and effective alternative for wound care, especially in resource-limited settings. The study's well-matched design and rigorous methodology lend credibility to the results, though further research is needed to confirm these findings and assess long-term outcomes. Honey dressings could play a crucial role in improving wound management, particularly where conventional treatments may be less effective.

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Data Availability Statement

Data supporting the study findings are available on request from the corresponding author [JAI]. The data are not publicly available due to ethical data transfer restrictions of IRB that could compromise the privacy of research participants.

Disclaimer

The views and opinions expressed in the submitted article are the author’s own and not the official position of the affiliated institutions.

Competing Interest Statements

The authors have declared that there is no competing interest exists.

Contributions

JA, AU, CLU, EM, CU, JN, AI, IN, FN, ENM, GB, CMM participated in all stages of this paper, from the study design, method, grant writing, data collection, analysis and paper writing.

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