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Bacterial Profile, Antibiotic Susceptibility Patterns and Associated Factors among Orthopedic Infection Suspected Cases in Selected Health Facilities of Wolaita Sodo, Southern Ethiopia

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Abstract

Background: Orthopedic infection is related with significant morbidity and mortality. However, the problem is not well investigated in resource constrained settings.

Objectives: This study is aimed at determining bacterial profile, antimicrobial susceptibility pattern and identifies associated factors among orthopedic infection.

Methods and materials: A cross-sectional study was conducted among 138 study participants visiting the selected hospitals in Wolaita Sodo from February to May 2019. Socio-demographic and clinical data were collected using a structured questionnaire. Swabs were also collected and inoculated to blood and MacConkey gar. Bacterial identification was done by colony morphology, gram stain and standard biochemical tests. Antimicrobial susceptibility tests were done using Kirby Bauer disk diffusion technique. Data were entered and analyzed using SPSS statistical software version 22.

Results: Swabs from 85 (61.6%) participants were culture positive. The prevalence of infection in trauma, surgical site infection, implant and hematogenous sources was 34.8%, 9.4% and 4.3% respectively. From 92 bacteria isolated, 48 (52.2%) were gram positives. *Staphylococcus aureus* and CoNS were the most frequent isolates among gram positives and while among gram negatives *Klebsiella pneumonia* 9 (9.8%) and *Citrobacter diversus* 6(6.5%) were the most frequent. Majority of gram-negatives showed resistance to the tested antibiotics. All the independent variables were not significantly associated with orthopedic infections.

Conclusion and recommendation: The most commonly isolated bacteria were *S. aureus*, CoNS and *K. pneumonia*. Efforts should be strengthened to minimize orthopedic infection due to *S. aureus*, CoNS and *K. Pneumonia* and further similar study is required.

Keywords: Orthopedic infection; Bacterial profile; Antimicrobial susceptibility pattern; Associated factors; Ethiopia

Abbreviations: ATCC: American Type Culture Collection; CLSI: Clinical and Laboratory Standards Institute; CoNS: Coagulase-Negative Staphylococci; LDC: Lysine Decarboxylase Test; MDR: Multiple Drug Resistance; MRSA: Methicillin-Resistant *Staphylococcus Aureus*; MSA: Mannitol Salt Agar; MSIS: Musculoskeletal Infection Society; SIM: Simon Indole Motility Medium; SOP: Standard Operating Procedures; SPSS: Statistical Package for Social Sciences; SSI: Surgical Site Infection; TSI: Triple Sugar Iron Agar; WHO: World Health Organization

Introduction

Orthopedic infection is an infection of the bone and joint associated structures [1,2]. Orthopedic infections are commonly caused by bacteria, which can be acquired either by endogenous (hematogenous infections) or exogenous routes (surgical site, trauma, and implant related infections) [3-5]. Orthopedic Surgical Site Infection (SSI), disseminated infection, vascular insufficiency, infection due to open fracture and hematogenous infection contributes to 2.6-41.9%, 47%, 34%, 2-16% and 7-19% of orthopedic infection, respectively [6-9]. Orthopedic infection is a global challenge occurring both in developed and developing countries, with alarming consequences in resource constrained settings such as increased medical cost, drug resistance to the commonly prescribed antibiotics, difficulty in infection management which results in significant mortality [10,11]. Hence, in orthopedic operating rooms, even one surgical-site infection is considered significant.

There are different strategies currently used to prevent and control orthopedic infection of the different strategies generating evidence through research is important to improve the prevention and control of orthopedic infection in resource constrained settings. In India, orthopedic infection related to SSI

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was observed with varying epidemiology from 4.4-12% [12-15]. In Africa, there are studies on postoperative SSIs, but there are no published study on all sources of orthopedic infection, antimicrobial susceptibility pattern and associated risk factors [16]. In Ethiopia, studies by Mengesha, et al. and Abrham, et al. considered only SSI and trauma related orthopedic infections, respectively [17,18] and did not consider identifying the possible risk factors. Therefore, this study is designed to determine the bacterial profile, antimicrobial susceptibility pattern and associated factors among all sources of orthopedic infection at Wolaita Sodo, Southern Ethiopia.

Materials and Methods

Study setting and design

This study was conducted at Wolaita Sodo christian general private hospital and Wolaita Sodo university referral governmental hospital, which are located in Wolaita Sodo town, in the Southern nation and nationalities regional state of Ethiopia. The town is 329 km due South away from Addis Ababa, the capital city of Ethiopia. The selected hospitals provide medical service, including orthopedic care to the Wolaita zone and the neighboring population.

Study design and population

A cross-sectional study was conducted from February to May 2019. This study was done among patients visiting the hospitals for orthopedic care. The study participants were those that were clinically suspected for orthopedic infection and able to provide written informed consent/assent. During the data collection time, a total of 327 patients visited the hospitals for orthopedic care. Considering single population proportion method (95% CI with 1.96, P (0.45) from India, d (5%)) and correction formula for less than 100,000 populations, a total of 138 orthopedic clinically suspected patients were included for this study [19]. The study participants were proportionally allocated to each hospital. Then, patients were recruited consecutively during the study period.

Data collection procedure

During the data collection, experienced clinicians were involved during the clinical diagnosis of orthopedic infections. Clinically suspected orthopedic patients were interviewed using a structured questionnaire to collect socio-demographic data (age, sex, occupation, educational status, and residence), clinical data (case type, duration of operation in minutes, and history of antibiotic prophylaxis and sources of orthopedic infections) and behavioral data (history of visiting traditional healers from the participants). Then specimens were collected by trained health professionals.

Sample collection, handling, and transport

Sterilized sample collection tubes and cotton tipped swabs were used. Swabs representative of the infected tissue (either deep surgical wound or pin site wound) were collected by a trained health professional. The skin surface was appropriately disinfected prior to specimen collection to minimize external contamination. The cotton swab was rotated on 1 cm 2 area of clean granulation tissue using gentle pressure to release tissue exudates. The swabs were put in a sterile test tube containing sterilized normal saline. Then the collected sample was transported to Sodo Christian microbiology laboratory within 30 minutes at room temperature and analyzed immediately.

Laboratory testing

Culture and identification: All collected specimens were inoculated on to primary isolation culture media (blood agar and MacConkey agar) and were incubated at 37ºC for 24-48 hrs. Positive cultures were inspected for their growth characteristics and then gram staining was performed to differentiate gram positives from gram-negative bacteria. Then standard biochemical tests were used to differentiate each bacterial species. For the gram-positive cocci species, catalase test was used to differentiate staphylococci from streptococci species and coagulase test was used differentiate *Staphylococcus aureus* and Coagulase-Negative *Staphylococcus* Species (CoNS). Triple Sugar Iron (TSI), simon's citrate agar, mannitol fermentation, urease, Lysine Decarboxylase (LDC), Sulfur Indole Motility (SIM), and oxidase tests were performed to differentiate Gram-negative bacteria species.

Antibiotic susceptibility test: Antimicrobial susceptibility testing was performed using modified Kirby-Bauer disk diffusion according to the Clinical and Laboratory Standards Institute (CLSI), 2018 guideline [20,21]. Bacterial isolates were tested against selected antibiotics based on the CLSI guidelines for selecting antibiotics for AST testing.

For gram-positive staphylococci: Tetracycline TE (30 µg), Erythromycin E (15 µg), Clindamycin (10 µg), and penicillin (10 µg) was used. For gram-negative rods isolates: Gentamicin GEN (10 µg), Chloramphenicol CHO (30 µg), Ciprofloxacin CPR (5 µg), Ampicillin (2 µg), Cefuroxime CFU (30 µg), Meropenem (10 µg), and Ceftazidime CAZ (30 µg) was used. Diameters of the zone of inhibition around the disc were measured in millimeters and were compared with the CLSI set disc diffusion zone length. Multi drug Resistance (MDR) was defined as acquired non-susceptibility to at least one agent in three or more antimicrobial categories.

Data quality assurance

Aseptic techniques were applied in all steps of specimen collection and inoculation onto culture media. Reagents and antimicrobial discs were checked for expiry date. Sterility of culture media was carried out by incubating 5% of the prepared media prior to inoculation. *Escherichia coli* (ATCC 25922), *Staphylococcus aureus* (ATCC 25923) and Pseudomonas aeruginosa (ATCC 27853) reference strains were used to control the performance of culture media and antibiotic discs.

Statistical analysis

The data were entered into the EPI Info version 7 (CDC, USA) every day. The data were imported from EPI Info and analyzed using Statistical Package for Social Sciences (SPSS) software version 22.0 (IBM, USA). Descriptive statistics were computed and data were presented using figures and tables. Binary logistic regressions were used to see the relationship between the dependent and independent variables. P-value of <0.05 was considered as statistically significant considering 95% level of confidence.

Ethics approval and consent to participate

The study protocol was evaluated and approved by the research ethics review committee of the college of health sciences, Mekele university and ethical clearance was obtained. Support letters were obtained from the respective hospitals. Written consent was obtained after explaining the objective of the study to participants and guardians/parents, respectively. All the information contained in the study was kept confidential. Laboratory examination results with a direct benefit in the health of the patients were informed to physicians. The consent involves the permission to disseminate the findings of the study through the scientific workshop and publish in reputable journals.

Results

Sociodemographic characteristics of study participants

During the study period, a total of 327 patients came to the hospitals for orthopedic care. From this, 138 cases were clinically suspected for orthopedic infections of these 138 patients, 104 (75%) were male. The median age and interquartile ranges of the study participants were 26 (17-37) years. The majority, 86 (62.3%) of study participants resided in a rural area. Farming was the prevailing occupation with 48 (47.5%) farmers in the study group. Over half of the study participants, 67 (51.1%) were attending elementary school. Majority of cases 97 (70.3%) were new patients. The majority, 48 (34.8%) of the study participants were with trauma (Table 1).

Table 1: Sociodemographic characteristics of orthopedic infection suspected patients (n=138) at selected Hospitals in Wolaita Sodo from February to May 2019.

Participant characteristics	Frequency n (%)
Sex	
Male	104 (75)
Female	34 (25)
Age*	
0-12	23 (16.7)
13-18	14 (10.1)
19-59	94 (68.1)
≥ 60 Years	7 (7.1)
Level of education	
No formal education	33 (25.2)
Primary school	67 (51.1)
Secondary school	23 (17.6)
Tertiary level	8 (6.1)
Occupation	
Government employee	8 (7.9)
Farmer	48 (47.5)
Merchant	29 (28.8)
Other	16 (15.8)
Residence	
Rural	86 (62.3)
Urban	52 (37.7)
Case type	
New (Outpatient)	97 (70.3)
Inpatient	41 (29.7)
*Adopted from classification of human age based on neural network using FG-NET aging database and wavelets	

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Bacterial profile among orthopedic infection suspected patients

From the study participants, 85 (61.6%) were a culture-confirmed orthopedic infection. From the 85 swabs, a total of 92 bacteria were isolated, of which 48 (52.2%) were Gram-positive bacteria. From Gram-positive bacteria, 29 (31.5%) and 19 (20.7%) were *Staphylococcus aureus* and CoNS, respectively. The frequently isolated species from Gram-negatives bacteria, were *Klebsiella pneumonae*, *Citrobacter diversus* and *Klebsiella oxy ica* with a prevalence of 9 (9.8%), 6 (6.5%) and 5 (5.4%), respectively. The prevalence of orthopedic infection among patients with trauma, surgical site infection, implants, and hematogenous infections were 48 (38.4%), 18 (13%), 13 (9.4%) and 6 (4.3%), respectively. Among trauma-related orthopedic infections, the most frequent bacteria were *S. aureus* 15 (27.3%), CoNS 13 (23.6%), K. oxytica 5 (9.1%), C. *diverseus* 4 (4.3%) and *Proteus mirabilis* 4 (4.3%). In surgical site orthopedic infections the most frequent bacteria isolated were, *K. pneumonae*, *S. aureus* and CoNS with prevalence of 5 (9.1%), 3 (18.8%) and 3 (18.8%), respectively. In implant-associated orthopedic infections, the predominant isolate were *K. pneumonia*, *S. aureus* and CoNS with 5 (31.3%), 3 (12%) and 3 (12%), respectively. In hematogenous orthopedic infections, *S. aureus* was isolated in 3 (60%). Of 85 culture-positive cases, eight isolates were with polymicrobial infections consisting of 2 (2.2%) *C. diversus*, 2 (2.2%) *K. pneumonia*, 1 (1.1%), *Enterobacter cloacae*, 1 (1.1%) *K. oxy ica*, 1 (1.1%) *Pseudomonas spp.* and 1 (1.1%) *Acinetobacter spp* (Table 2).

Factors associated with orthopedic infection

Binary logistic regression was performed on all associated factors and none of the independent variables were significantly associated with orthopedic infections in the present study (Table 2).

Table 2: Associated risk factors with orthopedic infection suspected patients (n=138) at selected hospitals in Wolaita Sodo from February to May 2019.

Variables	Orthopedic infection, n (%)	Crud odds ratio	
		95% (CI)*	P value
Age			
0-12	18 (78.3)	2.34(0.776-6.838)	0.14
13-18	6 (42.9)	0.469(0.15-1.47)	0.469
19-59	57 (62.6)	Reference	
≥ 60 Years	4 (40)	0.417(0.11-1.58)	0.417
Gender			
Male	63 (60.6)	Reference	
Female	22 (64.7)	1.193 (0.533-2.671)	0.668
Education status* (n=78)			
No formal education	15 (45.5)	0.528 (0.227-1.228)	0.138
Students elementary	42 (62.7)	Reference	
Secondary	15 (65.2)	1.19 (0.442-3.196)	0.731
Tertiary	6 (75)	1.9 (0.357-10.147)	0.451
Occupation* (n=61)			
Government employee	5 (62.5)	0.759 (0.228-4.49)	0.76
Farmer	27 (56.3)	0.584 (0.176-1.943)	0.381
Merchant	18 (62.1)	0.644 (0.177-2.339)	0.504
Others	11 (68.8)	Reference	
Residence			
Rural	46 (53.5)	Reference	
Urban	39 (75)	2.61 (1.223-5.563)	0.24

Case type			
Inpatient	25 (61)	0.994 (.047-2.1)	0.987
Outpatient	60 (61.9)	Reference last	
Antibiotic prophylaxis			
No	44 (62)	Reference	
Yes	41 (59.7)	0.968 (0.487-1.922)	0.925
****Surgery length (in min) (collected from medical records)* (n=46)**			
<120 minutes	38 (65.5)	Reference	
>120 minutes	8 (47.1)	0.468 (0.156-1-1.399)	
Sources of orthopedic infection			
Trauma	48 (100)	NA ***	
SSI	18 (100)	NA ***	
Implant	13 (100)	NA ***	
Hematogenous	6 (100)	NA ***	
Visiting traditional healers			
No	74 (61.7)	Reference	
Yes	11 (61.1)	1.024 (0.37-2.829)	0.964
*Confidence interval, ** the category for surgery time was adopted from: Prolonged operative duration is associated with complications: a systematic review and meta-analysis(64), but since we did not find study participants in each category we regrouped it considering the minimum surgery time (120 minutes) as cut-off point; ***do not fit for analysis.			

Antimicrobial susceptibility pattern of isolates

Out of 29 *S. aureus* isolates, 24 (82.8%) were sensitive to Clindamycin and 17 (58.6%) were sensitive for Erythromycin, while out of 19 CoNS isolates, 14 (73.7%) were sensitive for Clindamycin and 12 (63.2%) were sensitive for Erythromycin among tested antibiotics. *S. aureus* was most commonly resistant to Penicillin 22 (79.3%), Tetracycline 17 (62.1%) while CoNS was most commonly resistant to Penicillin 16 (84.2%) and Tetracycline 10 (52.6%) among tested drugs (Table 3). Forresistance profiles, both gram-negative and gram-positive isolates showed Multiple Drug Resistance (MDR). *S. aureus* had a high resistance pattern with 23 (79.3%) resistant to penicillin, 18 (62.1%) resistant to Tetracycline. CoNS also had a high resistance pattern with 16 (84.2%) resistant to penicillin and 10 (52.6%) resistant to Tetracycline. Among gram-negative rods, all isolates showed complete resistance to Amoxicillin, in addition, *K. pneumonia*, *K. oxytica*, and *Enterobacter cloacae* showed complete resistance to Gentamycin, Cefuroxime, and Ciprofloxacin, while *C. diversus* showed complete resistance to Meropenem and Cefuroxime and also 5 (83.3%) resistance to Chloramphenicol and Gentamycin (Tables 3 and 4).

Table 3: Bacterial profile and antimicrobial resistance pattern of gram positive isolates (n=48) at selected hospitals in Wolaita Sodo from February to May 2019.

Antibiotic discs tested															
Isolate (n=48)	**Clindamycin**			**Oxacillin**			**Penicillin**			**Tetracycline**			**Erythromycin**		
	***R (%)**	**S (%)**	**I (%)**	**R (%)**	**S (%)**	**I (%)**	**R (%)**	**S (%)**	**I (%)**	**R (%)**	**S (%)**	**I (%)**	**R (%)**	**S (%)**	**I (%)**
***S. aureus* (29)**	5 (17.2)	24 (82.8)	NA	NA	NA	0 (0)	23 (79.3)	6 (20.6)	0 (0)	18 (62.1)	11 (37.9)	0 (0)	12 (41.4)	17 (58.6)	0 (0)
CoNS (19)	5 (26.3)	14 (73.7)	0(0)	11 (57.9)	8 (42.1)	0(0)	16 (84.2)	3 (15.8)	0 (0)	10 (52.6)	9 (47.4)	0 (0)	7 (36.8)	12 (63.2)	0 (0)
*R=Resistant *I=Intermediate *S=Sensitive, NA=Not Applicable															

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Table 4: Bacterial profile and antimicrobial resistance pattern of gram negative isolates (n=44) at selected hospitals in Wolaita Sodo from February to May 2019.

Antibiotic discs tested																					
Isolate (n=44)	**Meropenem**			**Gentamycin**			**Ampicillin**			**Cefuroxime**			**Chloramphenicol**			**Ciprofloxacin**			**Ceftazidime**		
	***R(%)**	**S (%)**	**I (%)**	**R(%)**	**S (%)**	**I (%)**	**R(%)**	**S(%)**	**I(%)**	**R(%)**	**S(%)**	**I(%)**	**R (%)**	**S (%)**	**I (%)**	**R(%)**	**S (%)**	**I (%)**	**R(%)**	**S (%)**	**I(%)**
K. pneumoniae (9)	4 (44.4)	0 (0)	5 (55.6)	9 (100)	0 (0)	0(0)	9 (10)	0(0)	0(0)	9 (10)	0 (0)	0(0)	9 (10)	0 (0)	0(0)	9 (10)	0(0)	0(0)	NA	NA	NA
K. oxytica (5)	2 (375)	2 (375)	1 (25)	5(100)	0(0)	0(0)	5 (100)	0(0)	0(0)	5 (100)	0 (0)	0(0)	4 (80)	0 (0)	1(20)	2 (40)	2 (40)	1(20)	NA	NA	NA
K. ozaenae (1)	0 (0)	1 (100)	0 (0)	0 (0)	1 (100)	0 (0)	1 (100)	0(0)	0(0)	1 (100)	0 (0)	0(0)	1 (100)	0 (0)	0(0)	1 (100)	0 (0)	0 (0)	NA	NA	NA
K. rihinoscler (1)	0 (0)	0 (0)	1 (100)	0 (0)	1 (100)	0 (0)	1 (100)	0(0)	0(0)	1 (100)	0 (0)	0(0)	0 (0)	1 (100)	0(0)	0 (0)	1 (100)	0 (0)	NA	NA	NA
Citrobacter (2)	0 (0)	1 (100)	1 (100)	1 (50)	1 (50)	0(0)	2 (100)	0(0)	0(0)	2 (100)	0 (0)	0(0)	1 (50)	1 (50)	0(0)	1 (50)	1 (50)	0 (0)	NA	NA	NA
C. diversus (6)	6 (100)	0 (0)	0 (0)	5 (833)	1 (167)	0(0)	6(100)	0(0)	0(0)	6(100)	0 (0)	0(0)	5 (833)	1 (167)	0	3 (50)	3 (50)	0 (0)	NA	NA	NA
P. mirabilis (4)	1 (25)	3 (75)	0 (0)	1 (25)	3 (75)	0 (0)	4 (100)	0(0)	0(0)	3 (75)	1(25)	0(0)	4 (100)	0 (0)	0(0)	2 (50)	2 (50)	0 (0)	NA	NA	NA
S. typimrium (1)	0 (0)	1 (100)	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	1(0)	0(0)	0 (0)	1 (100)	0(0)	0 (0)	1 (100)	0(0)	0 (0)	1 (100)	0 (0)	NA	NA	NA
E. cloacae (4)	2 (50)	0 (0)	2 (50)	4 (100)	0(0)	0 (0)	4 (100)	0(0)	0(0)	4(100)	0 (0)	0(0)	3 (75)	1 (25)	0(0)	4 (100)	0 (0)	0 (0)	NA	NA	NA
Serratia spp. (1)	0 (0)	1 (100)	0 (0)	0 (0)	1 (100)	0 (0)	1(100)	0(0)	0(0)	1 (100)	0(0)	0(0)	1 (100)	0(0)	0(0)	0(0)	1(100)	0 (0)	NA	NA	NA

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E. coli (1)	1(100)	0(0)	0(0)	1(100)	0(0)	0(0)	1(100)	0(0)	0(0)	1(100)	0(0)	0(0)	1(100)	0(0)	0(0)	1(100)	0(0)	0(0)	NA	NA	NA
E. aerogens (4)	3(75)	1(25)	0(0)	3(75)	1(25)	0(0)	4(100)	0(0)	0(0)	4(100)	0(0)	0(0)	4(100)	0(0)	0(0)	3(75)	1(25)	0(0)	NA	NA	NA
S. typhi (1)	0(0)	1(100)	0(0)	0(0)	1(100)	0(0)	1(100)	0(0)	0(0)	0	1(100)	0(0)	0	1(100)	0(0)	0(0)	1(100)	0(0)	NA	NA	NA
Acinetobacter spp. (1)	0(0)	0(0)	1(100)	1(100)	0(0)	0(0)	NA	NA	NA	NA	NA	NA	NA	NA	NA	1(100)	0(0)	0(0)	1(100)	0(0)	0(0)
Pseudomonas spp. (3)	0(0)	1(33 3)	2(66 7)	2(66 7)	0(0)	1(33 3)	NA	NA	NA	NA	NA	NA	NA	NA	NA	1(33 3)	0(0)	2(66 7)	2(66 7)	1(33 3)	0(0)
*R=Resistant *I=Intermediate *S=Sensitive NA=not applicable																					

Discussion

Orthopedic infection is defined as an infection of bones and joints leading to impaired mobility, complication to surgical procedures, increased morbidity, irreversible joint stiffness, permanent disability and even amputation [22]. Therefore knowing the most common bacterial isolates of infection, determining their antimicrobial resistance pattern and associated factors will help to provide an effective empiric antibiotic selection for patients until a final culture can be obtained and minimize on-going infection and boney destruction.

In the present study, the overall prevalence of orthopedic infections was 61.6%. The findings from this study are higher than another study done in India. The high prevalence may be due to poor infection prevention, contamination of surgical instrument and number of personnel in the operating room [23]. This study has lower prevalence compared to another study done in India 68%, the higher prevalence in the Indian study may be due to the specimen collected was from wound [24]. The prevalence of trauma and orthopedic SSI infection in the present study were 34.8% and 13% respectively. The prevalence of trauma-related to orthopedic infection in this study is relatively similar to the findings in other American and Ethiopian studies which found a prevalence of 41% [25]. Vishwajith, et al. reported a higher prevalence of 95% [26]. This high prevalence could be due to contaminated open fracture wounds which could raise the prevalence up to 70.3% according to the Gustilo and JT Anderson trauma classification [27]. The finding of SSI in this study is 13%, which is similar to a study in Saudi Arabia and India with prevalence rates of 12-13% [28]. The increased prevalence in this study might be poor infection prevention measures and poor operation room ventilation [29]. Implementing good infection prevention measures, decreasing operating room traffic and maintaining operating room air quality may help to minimize SSI in orthopedic surgeries in the future.

Moreover, the prevalence of implant and hematogenous infections were 9.4% and 4.3%, respectively. The rate of implant infections in this study is consistent with findings in the majority of implant studies which is 1-9% [30]. In trauma cases, the prevalence of implant infection can range from 1-30% [31]. Conversely, the prevalence of hematogenous infection is low compared to other similar studies in the USA which are 7% and 34%. This might be due to age differences between the American study and this study. Hematogenous orthopedic infection was more common in adults in our study, whereas in the American studies hematogenous orthopedic infection was more common in children and after placement of orthopedic implants [32]. The prevalence in this study is more similar to a study conducted in India that found a prevalence of hematologic orthopedic infections of 5.13%. Their study only reviewed hematogenous infection after orthopedic implant, yet had a similar rate [33].

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Addressing the bacterial profile of orthopedic infections, the frequent bacterial isolates among orthopedic infections in this study were *S. aureus* 31.5% and CoNS 20.7%. This is similar to a study in India with a prevalence of 25% and 20% [34] respectively. However, a higher prevalence of *S. aureus*, 40%, 43.75%, isolates were reported by Lakshminarayana, et al. and Valya B [5]. This may be due to these bacteria arising from endogenous sources, the environment, surgical instruments, and healthcare workers. CoNS was the second most frequent bacterial isolate, accounting for 20.7% of infections. This rate is similar to the findings in Aikaterini Masgala study of 20% [34] but higher than Das, et al. which was 5.4%. This discordance may be due to the small number of isolates in their study. The next most frequent isolates were *Klebsiella spp.*, 17.4%, and *Citrobacter*, 8.7%. A study in the USA reported a similar rate of *Klebsiella spp.* Infections at 17% while Lakshminarayana, et al. reported a slightly lower prevalence at 10.1% this is maybe due to a low number of isolates.

Furthermore, *S. aureus* infection rates were similar in this study and other both in SSI and after implant placement. A 40% and 48.7% prevalence was found in a study conducted in India from SSI [37]. In implants, a rate of 36.7% was found in Khosravi AD, et al. [36]. This was very consistent with the rate of 35.2% in this study. This demonstrates that staphylococci are the predominant bacterial isolate in orthopedic device-related and SSI infections. In the previous Ethiopian study, the prevalence of *S. aureus* in trauma patients was 14.8%, while in the present study, it was 27.3%. This difference may be due to the relatively high number of infected trauma patients in the present study.

Regarding antimicrobial susceptibility testing, the resistance level of *S. aureus* in this study for Penicillin was 79.3%, which is similar to a study in Egypt that had rates of 86.7% [38]. In addition to this, in Egyptian study, CoNS showed 66.7% and 100% resistance to penicillin, which was similar to the present study that showed CoNS resistance rates of 84.2% for Penicillin. In this study, *K. pneumonia* shows 100% resistance to ampicillin and Gentamycin, and in the Egyptian study, there was also a 100% resistance to Ampicillin but only 62.7% resistance to Gentamycin. A significant association between orthopedic infection and independent variables was not found. However, other similar studies found associated risk factors for older age, surgery length, trauma and antibiotic prophylaxis.

The limitations of this study are, due to the small sample size, we were not able to perform logistic regressions for some independent variables. Future studies could expand on the sample size to expand the analysis of their association with orthopedic infections.

Conclusion

In this study, 85 (61.6%) of the suspects were having an orthopedic infection and none of the independent variables were significantly associated with orthopedic infection. The most frequent bacterial isolates were *S. aureus*, CoNS, and *K. pneumonia*. *S. aureus* and CoNS were sensitive to Clindamycin and Erythromycin and but high resistance Tetracycline, and penicillin whereas the majority of gram-negatives show resistance to tested antibiotics. Further studies in different sources of orthopedic infection are required.

Competing Interests

The authors have no competing interests to declare.

Authors Contribution

TM participated in the conception of the title and study design, data collection, data analysis, data entry and writing the manuscript. SN participated in the study during design and analysis. GG, ET participated in design and data cleaning. AK was involved in the study monitoring. All authors read and approved the final manuscript.

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