ORIGINAL ARTICLE

Spectrum of antibiotic sensitivity of bacterial flora isolated from dental laboratory surfaces at a private dental hospital in Lahore

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ABSTRACT

Background and Objective: Dental laboratory surfaces are contaminated by various microorganisms that can cause infections among staff and students. This observational study aimed to identify different types of microbial flora present on different surfaces of dental laboratories and determine the antibiotic sensitivity of the isolates.

Methods: This cross-sectional observational study was conducted in the dental laboratory of a dental school in Pakistan from April 2023 to April 2024. Eleven samples were collected from randomly selected surface areas in the dental laboratory during working hours of the day without any prior disinfection using Amies agar gel transport swabs and transferred to the laboratory for culture and sensitivity test. Visible growth was observed on all culture plates. Colonies grown on blood and MacConkey agar plates were tested using standard microbiological methods.

Results: Analysis of swabs taken from the dental laboratory surfaces showed microbial contamination with *Acinetobacter baumannii* (63%), *Klebsiella pneumoniae* (36%), and *Staphylococcus hominis* (27%), with absence of any fungal growth. These microorganisms showed variable resistance to various antibiotics, including ampicillin, co-amoxiclav, co-trimoxazole, meropenem, ciprofloxacin, Cefotaxime, and levofloxacin.

Conclusion: This study found pathogenic microorganisms resistant to most antibiotics, highlighting the need to update disinfection practices commonly used in our dental laboratories.

Keywords: *Acinetobacter baumannii*, antibiotic, antimicrobial resistance, dental laboratory.

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Introduction

Dental laboratories are dedicated to the fabrication and customization of dental appliances such as dentures, bridges, crowns, and orthodontic devices to support the delivery of oral healthcare to patients.[1] These environments involve frequent interaction among students, technicians, and equipment, thereby increasing the risk of microbial contamination. Laboratory surfaces often serve as reservoirs for pathogenic and opportunistic microorganisms, posing a significant risk to dental personnel, patients, and immunocompromised individuals.[2]

Bacteria that are not part of the normal flora can cause serious infections if transmitted through prostheses fabricated in contaminated laboratory areas. Therefore, infection control protocols should be implemented before handling clinical items in dental settings. Contamination of dental laboratories with antibiotic-resistant strains presents a substantial challenge in the effective treatment of dental diseases.[3]

Dental laboratories contain a diverse range of surfaces capable of harboring pathogenic microorganisms. Work surfaces where dental prostheses are fabricated and customized for individual patients can serve as major sources of microbial proliferation.[4] Additionally, dental appliances, being personalized products, may become vectors for transmission if produced in contaminated environments.

Equipment surfaces, including machinery and instruments, are also potential sites of infection.[5]

Microbial contamination remains a growing concern among dental personnel, particularly in laboratory settings. Although disinfection practices are designed to maintain a clean environment, they often fall short of completely eradicating all microorganisms.[6] A 2021 study identified commonly encountered bacterial species in dental environments, including *Klebsiella pneumoniae, Mycobacterium tuberculosis, Escherichia coli, Streptococcus pneumoniae, Pseudomonas aeruginosa*, and *Legionella pneumophila*.[3] Ideally, there should be no microbial contamination, as it contributes to cross-contamination within clinical and laboratory settings.

Effective infection control is reliant on the identification of contaminants and a clear understanding of their antibiotic resistance profiles. While previous studies have reported various microorganisms in clinical dental settings,[7,8] limited data exist regarding contamination on laboratory surfaces, especially in undergraduate teaching institutions. This study was designed to assess the microbial contamination of dental laboratory surfaces and to determine the antibiotic resistance patterns of isolated pathogens. The findings aim to support improved infection control protocols and raise awareness among staff and students regarding potential contamination risks.

Methods

This cross-sectional study was conducted in the Dental laboratory of Fatima Memorial College of Dentistry, Lahore, in collaboration with the Microbiology Laboratory of the same hospital. The Institutional Review Board approval was obtained prior to study initiation. Eleven samples were collected using a random selection method from the following surfaces: four benchtops, a dental vibrator, two micromotors, a trimmer, a casting machine, a polishing lathe, and a polishing buff. None of the surfaces was cleaned before sampling.

Sample swabs were collected using Amies agar gel transport swabs and processed within one hour of collection. Blood agar and MacConkey agar were used for bacterial culture, while Sabouraud dextrose agar was used for fungal detection. Bacterial plates were incubated at 37°C for 18-24 hours, whereas Sabouraud agar plates were incubated at 25°C-30°C for up to 7 days. No fungal growth was observed.

Bacterial colonies were identified based on colony morphology, Gram staining, and analysis via the VITEK-2 Compact System. Antibiotic susceptibility testing was performed using VITEK AST cards and interpreted according to the Clinical and Laboratory Standards Institute 2022 guidelines.[9] Quality control of the culture media was maintained through manufacturer-recommended storage conditions and sterility verification.

Randomization of surface area selection was performed using a random number generator. The last routine disinfection of the dental laboratory occurred more than 24 hours prior to sample collection. All microbial specimens were disposed of in accordance with institutional biohazard waste protocols.

Statistical analysis

Data were entered and analyzed using SPSS version 23 statistical software. Results were presented as the total number of pathogens isolated and their corresponding frequencies and percentages. Surface-wise contamination analysis was determined using cross-tabulation: type of

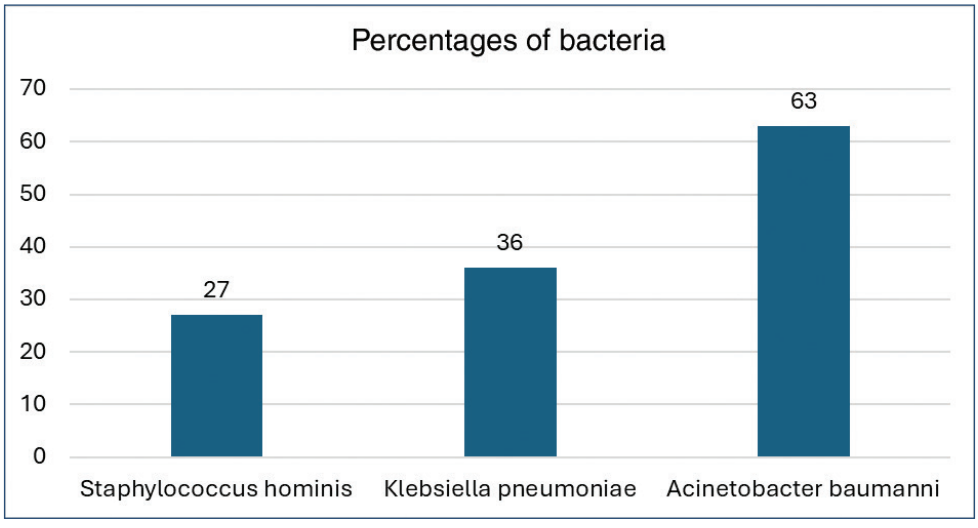

Figure 1. *Percentages of bacteria isolated from dental laboratory surfaces.*

surface (benchtop, micromotor, lathe, etc.) versus presence/absence of contamination by using Fisher's exact test.

Results

Visible microbial growth was observed in 10 out of 11 samples. The most frequently isolated organisms were *Acinetobacter baumannii* (*n* = 7, 63%), *K. pneumoniae* (*n* = 5, 36%), and *Staphylococcus hominis* (*n* = 3, 27%) (Figure 1). No fungi were isolated (Table 1). Fisher's exact test did not reveal a significant difference between benchtop and non-benchtop surfaces ($p > 0.05$).

Table 1. *Bacterial isolates from different laboratory surfaces.*

	Site	Microbial flora/Isolates
1	Bench top for students	*Klebsiella pneumoniae*
2	Micromotor (Dental ceramics)	*Klebsiella pneumonia* and *Acinetobacter baumannii*
3	Dental vibrator	*Acinetobacter baumannii*
4	Dental trimer	*Acinetobacter baumannii*
5	Dental casting machine	*Acinetobacter baumannii*
6	Micromotor (Prosthodontics dental Laboratory)	*Staphylococcus hominis*
7	Benchtop for dental technicians	*Staphylococcus hominis*
8	Polishing lathe	No growth
9	Polishing buff	*Klebsiella pneumoniae and Staphylococcus hominis*
10	Benchtop dental materials	*Acinetobacter baumannii* and *Klebsiella pneumoniae*
11	Benchtop dental ceramics	*Klebsiella pneumoniae*
		Acinetobacter baumannii

Antimicrobial susceptibility testing of all isolates revealed varying resistance patterns. For instance, *A. baumannii* was mostly resistant to ampicillin, co-amoxiclav, meropenem, and ciprofloxacin, but sensitive to doxycycline and gentamicin. *Klebsiella pneumoniae* showed resistance to several antibiotics, including cefotaxime and ampicillin. *Staphylococcus hominis* was sensitive to clindamycin and vancomycin, but resistant to levofloxacin and ciprofloxacin (Table 2 and Figures 2-4)

Discussion

The findings of this study underscore the microbial contamination of dental laboratory surfaces by opportunistic pathogens such as *A. baumannii*, *K. pneumoniae*, and *S. hominis*, with significant implications for infection control and antimicrobial resistance in healthcare settings. Three opportunistic pathogens, *A. baumannii*, *K. pneumoniae*, and *S. hominis,* were identified, all of which are associated with nosocomial infections. *Acinetobacter* is particularly problematic due to its multidrug resistance. *Klebsiella pneumoniae* contamination on laboratory surfaces has not been widely reported in Pakistan. Although *S. hominis* is typically a skin commensal, it can cause infections in vulnerable patients. In contrast, a study from Iran isolated a wider range of pathogens from pumice, a polishing stone used in dental laboratories. These included *A. lwoffii*, *Bacillus cereus*, *Staphylococcus aureus*, *P. aeruginosa*, diphtheroids, *Serratia marcescens*, *Enterobacter aerogenes*, *Morganella morganii*, *Providencia rettgeri*, *Staphylococcus albus*, and

Table 2. *Antimicrobial susceptibility of bacterial isolates.*

Microorganism	*n*	Antimicrobial susceptibility testing		
		Sensitive	Intermediate	Resistant
Klebsiella pneumoniae	5	Ceftazidime Cefotaxime	Gentamicin	Ampicillin Co-amoxiclav Co-trimoxazole Meropenam Ciprofloxacin
Acinetobacter baumannii	7	Doxycycline Gentamicin	Ciprofloxacin	Meropenem Cefotaxime Ampicillin Amoxicillin Co-amoxiclav
Staphylococcus hominis	3	Gentamycin Clindamycin Erythromycin Vancomycin Co-amoxiclav		Ampicillin Amoxicillin Levofloxacin Ciprofloxacin

"Overall, 10 out of 15 (66.7%) isolates demonstrated resistance to at least one antibiotic. *Klebsiella pneumoniae* showed the highest resistance burden (100% resistant to ≥1 antibiotic), while *Staphylococcus hominis* retained sensitivity to multiple agents such as vancomycin and gentamicin. Fisher's exact test revealed no statistically significant association between organism type and resistance category ($p > 0.05$), likely due to small sample size."

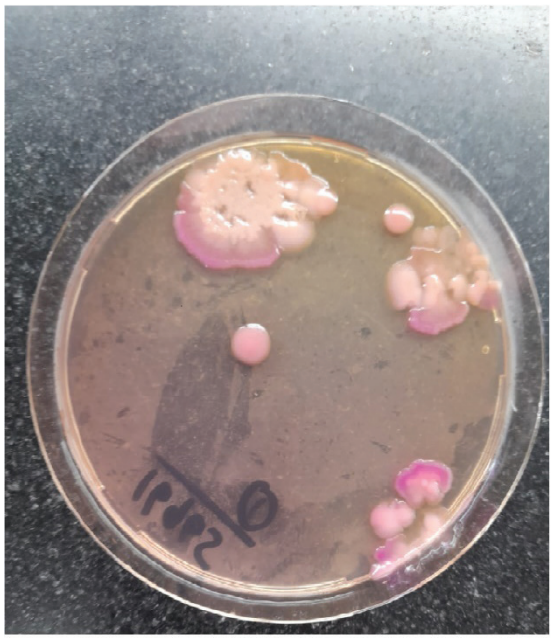

Figure 2. *Klebsiella pneumoniae colonies on MacConkey agar.*

Figure 3. *Acinetobacter baumannii colonies on MacConkey agar.*

Streptococcus sanguis.[10] A recent study from Sargodha, Pakistan, reported contamination of dental clinics by various pathogens, including *Corynebacterium* (23%), *Acinetobacter radioresistens* (12%), *K. pneumoniae* (10%), and *E. coli* (2.08%)[8]. *Acinetobacter* is a round to rod-shaped, Gram-negative bacterium with many strains commonly found in soil and water. Among these, *A. baumannii* is the most infectious strain in humans. It can colonize the human body without causing symptoms and is often secreted through sputum and wound exudates, leading to infections. These

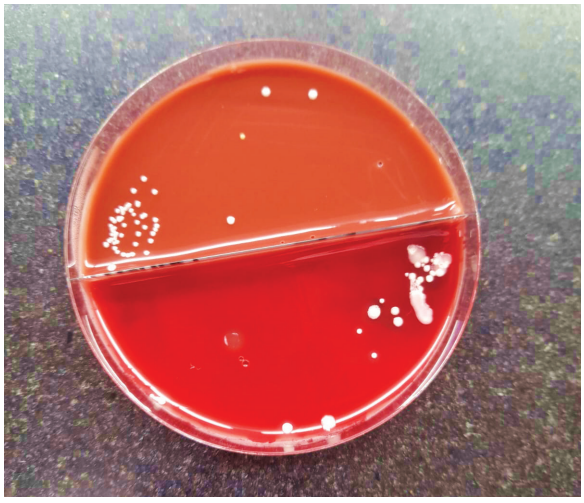

Figure 4. *Staphylococcus hominis colonies on blood agar.*

bacteria can persist on environmental surfaces and shared equipment for extended periods and are a known cause of hospital-acquired infections.[11] They readily spread through contaminated surfaces and hands, causing infections of the bloodstream, urinary tract, and lungs. Recent strains have also exhibited multidrug and carbapenem resistance.[12] Other studies have reported *A. baumannii* contamination in dental laboratories, dental units, and lounge specimens.[3] *Klebsiella pneumoniae* is a Gram-negative, lactose-fermenting rod and facultative anaerobe that can cause a wide range of infections, including pneumonia, bloodstream infections, wound or surgical site infections, and meningitis.[13] While *K. pneumoniae* contamination has been reported in dental units, we did not find any studies specifically reporting its presence in dental laboratory specimens.[14] A unique pathogen identified on laboratory surfaces in our study was *S. hominis*. To our knowledge, no previous studies have reported contamination of dental laboratory surfaces with *S. hominis*. It is a gram-positive, coagulase-negative bacterium typically present as a skin commensal but can occasionally cause endocarditis, pyoderma, or wound infections, particularly in immunocompromised individuals.[14,15]

Drug resistance among these pathogens poses an additional challenge, especially in countries such as Pakistan with high mortality rates due to antimicrobial resistance.[16] Bacterial pathogens can develop resistance through mechanisms such as horizontal gene transfer, spontaneous mutations, plasmid-encoded resistance genes, and biofilm formation, which reduces antibiotic penetration. These factors, combined with antibiotic misuse and overuse, contribute to ongoing resistance, even against newly developed drugs.[17] In our study, *K. pneumoniae* exhibited resistance to a wide range of antibiotics, including

ampicillin, co-amoxiclav, co-trimoxazole, meropenem, and ciprofloxacin. The 2019 Global Research on Antimicrobial Resistance report documented increased resistance in *K. pneumoniae*, associated with rising mortality rates (34,400 deaths) in Pakistan.[17] Similarly, a study from Iran reported high resistance levels in *K. pneumoniae* to commonly used antibiotics such as amikacin, aztreonam, chloramphenicol, ciprofloxacin, co-trimoxazole, gentamicin, and cefotaxime.[18] In contrast, the *K. pneumoniae* strain isolated in our study showed resistance specifically to cefotaxime. *Acinetobacter baumannii* in our study was found to be sensitive to doxycycline, gentamicin, and ciprofloxacin. However, a study from Kenya reported that *A. baumannii* isolated from healthcare environments was resistant to ciprofloxacin (76%), tobramycin (37%), and meropenem (27%).[19] In our study, *A. baumannii* isolates were also resistant to meropenem and other commonly used antibiotics.

Staphylococcus hominis showed resistance to levofloxacin and ciprofloxacin in our study. An Indian study has reported *S. hominis* to be 87.5% resistant to penicillin, 50% to erythromycin, 62.5% to clindamycin, and 37.5% to ciprofloxacin.[20] In contrast, our isolates were sensitive to clindamycin, amoxicillin, and co-amoxiclav, among other antibiotics (Table 2). No fungal contamination was observed in our laboratory isolates, in contrast to other studies that reported contamination of dental laboratories with fungi such as *Aspergillus niger*, *Fusarium* spp., *Aspergillus flavus*, *Cephalosporium* spp., and *Candida* spp.[18,19]

In Pakistan, poor health literacy, unrestricted access to antibiotics, and weak healthcare infrastructure are major contributors to antibiotic resistance.[21] Although the microbial diversity observed in our study was lower than that reported in the literature, the high prevalence of multidrug-resistant strains underscores the urgent need to implement standardized cleaning protocols, routine disinfection, and regular microbiological surveillance in dental laboratories. Additionally, improved training for students and laboratory technicians on infection control practices is essential to reduce microbial burden and prevent cross-contamination. Strengthening evidence-based national antibiotic stewardship programs is imperative to curb the spread of resistant organisms. Future investigations should focus on elucidating the pathways of cross-contamination between dental laboratories and clinical environments to better safeguard both patients and healthcare personnel.

Limitations of the Study

This study has some limitations, including a small sample size, the absence of fungal isolates, and a single time-point for sample collection. Despite these limitations, the findings provide valuable baseline data on microbial contamination and resistance patterns in dental laboratory environments and can serve as a reference for future multi-center or longitudinal research.

Conclusion

Dental laboratory surfaces serve as reservoirs for antibiotic-resistant opportunistic pathogens, highlighting a potential but often overlooked source of healthcare-associated infections. The findings reinforce the urgent need to implement rigorous and standardized disinfection protocols, coupled with robust infection control measures, to minimize contamination risks within laboratory settings.

Conflict of interest

None to declare.

Grant support and financial disclosure

None to disclose.

Ethical approval

The ethical approval of the study was obtained from the Institutional Review Board of the Fatima Memorial Hospital College of Medicine & Dentistry, Lahore, Pakistan vide Letter No. FMH-14/03/2023-IRB-1191 dated: 21-03-2024.

Authors' contribution

AQ, AI: Conceptualization and design of the study, drafting of manuscript, critical intellectual input

AB, ANC, AS, ZWA: Drafting of manuscript, acquisition and analysis of data, literature review

MSM, MN: Drafting of manuscript, analysis of data, literature review, critical intellectual input

ALL AUTHORS: Approval and responsibility of the final version of the manuscript to be published.

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