

EVALUATION OF DISINFECTION METHODS FOR SILICONE INTERCEPTION DEVICES IN ORTHODONTICS: COMBINING UVC LIGHT AND ANTIBACTERIAL TABLETS

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ABSTRACT

Aim of Study: This study aimed to assess the effectiveness of two disinfection methods—chemical-based cleaning with antibacterial tablets and a combination of UVC light and tablets—on silicone interception devices used in interceptive orthodontic treatment. **Materials and Methods:** Four devices were sectioned into three equal parts and divided into three groups: control (untreated), chemically cleaned (MyOClean antibacterial tablets), and disinfected with UVC light and tablets. Microbial samples were collected, cultured on UTI Chromogenic and Blood Agar media, and analyzed for bacterial growth and antibiotic susceptibility. **Results and Discussion:** The control group showed bacterial positivity within 24 hours, whereas the chemically and UVC-treated groups delayed bacterial growth to 48 hours, demonstrating the effectiveness of these methods in reducing bacterial contamination. Antibigrams of *Staphylococcus aureus* revealed high susceptibility to most antibiotics, with intermediate susceptibility noted for ciprofloxacin. **Conclusion:** The combination of UVC light and antibacterial tablets showed statistically superior disinfection outcomes ($p \leq 0.05$) and represents a promising strategy for improving the hygiene of orthodontic appliances. These findings provide evidence-based recommendations for reducing microbial contamination and addressing antimicrobial resistance in orthodontic practice.

Key words: orthodontic interception devices, silicone appliances, UVC light disinfection, antibacterial tablets, biofilm reduction, antimicrobial resistance, orthodontic hygiene, *Staphylococcus aureus*, antibiogram.

INTRODUCTION

The proper hygiene of orthodontic interception devices is critical for preventing microbial colonization and ensuring the effectiveness of early orthodontic treatments. Silicone-based interception devices, widely used for their flexibility and adaptability, are particularly susceptible to biofilm formation due to their elastic nature and prolonged exposure to the oral environment. Effective disinfection methods are essential to maintain

these devices' functionality and prevent adverse effects associated with microbial contamination, such as infections or impaired device performance (1,2).

Various disinfection methods, including chemical solutions and ultraviolet (UV) light devices, have been evaluated for their antimicrobial efficacy. Chemical disinfectants, such as potassium caroate-based antibacterial tablets, offer a convenient cleaning solution; however, their long-term

impact on material integrity and bacterial resistance is a growing concern (3). Meanwhile, UVC-based disinfection systems have demonstrated promising results in reducing microbial loads on orthodontic materials without the use of harsh chemicals, making them a viable alternative to traditional cleaning methods (4–6).

Recent studies have highlighted the importance of evaluating the efficiency of disinfection methods in reducing biofilm adhesion and bacterial colonization on orthodontic appliances. For instance, Garcez et al. demonstrated the effectiveness of antimicrobial photodynamic therapy in disinfecting orthodontic devices, emphasizing its role in clinical applications (6). Similarly, Lessa et al. reported significant reductions in microbial adhesion on orthodontic appliances when subjected to rigorous cleaning protocols (3). Studies have also investigated the effects of disinfection on silicone materials used in dental applications, such as impressions. Wezgowiec et al. found that UVC and gaseous ozone disinfection methods were effective without compromising the dimensional stability of silicone materials, suggesting their applicability for orthodontic appliances (7). Additionally, Moufiti et al. assessed the design and efficacy of UV light cabinets for dental disinfection, highlighting their potential to enhance microbial safety in clinical settings (8).

However, further research is needed to compare the relative efficacy of chemical and UVC disinfection methods, particularly for silicone-based materials.

This study aims to assess the effectiveness of two disinfection methods—chemical-based cleaning with antibacterial tablets and a combination of UVC light and tablets—on silicone interception devices used in interceptive orthodontic treatment. By

analyzing the bacterial cultures and antibiograms obtained from treated devices, this research seeks to establish evidence-based recommendations for maintaining the hygiene of orthodontic appliances while considering the rising concerns of antimicrobial resistance.

MATERIALS AND METHODS

In this study, four silicone-based interception devices (Fig.1) were examined. These devices were worn by patients for a period of 12 months during interceptive orthodontic treatment. The microbiological examination of the devices was conducted in collaboration with the "Louis Țurcanu" Emergency Clinical Hospital for Children in Timișoara.



Figure 1. Orthodontic interception devices

Inclusion Criteria:

- clinically healthy patients with no personal pathological history.
- patients with good oral hygiene and no carious lesions.
- patients treated with a mobile silicone orthodontic appliance due to minor dental discrepancies for early treatment in the mixed dentition phase.

Exclusion Criteria:

- patients with poor oral hygiene and multiple carious lesions.
- cases with pathological conditions.
- patients with permanent dentition.

Working Protocol:

The following devices and equipment were used in the study:

- Camera: DSLR camera – Canon 70D
- Thermostat: ICO150MED thermostat, series 0719.0078
- Culture media: UTI Chromogenic and Blood Agar

Additionally, the Kibatine lamp (Fig. 2) and MyOClean antibacterial tablets were used to compare their effectiveness in reducing bacteria on the orthodontic interception devices made from elastic material.



Figure 2. Kibatine Lamp

MyOClean Tablets (Fig. 3) are used for cleaning orthodontic appliances and dental aligners, following these steps:

- the interception device is brushed with a toothbrush before the cleaning process.
- in a glass of warm water (100-200 ml / max 35°C), the tablet and the device are placed, ensuring the device is fully submerged.
- the interception device should be left in the solution for at least 15 minutes.
- after the solution's action time is complete, the device is thoroughly rinsed under running water.
- finally, the device is dried and stored properly.



Figure 3. MYOClean tablets

The study involved the use of mobile silicone appliances worn by patients for 12 months. The appliances were divided into three groups: Group 1 – Control, Group 2 – MyOClean Tablets, and Group 3 – UVC + Tablets.

After cleaning, samples were collected and incubated in the thermostat for 24 hours for Group 1 and 48 hours for the other two groups. Subsequently, antibiograms were performed for each isolated bacterium (Fig. 4).

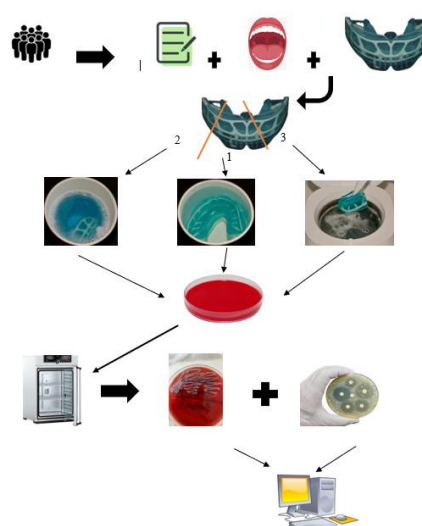


Figure 4. Working protocol

The interception devices were sectioned into three equal parts (Fig.5) to form three groups:

- control sample

- sample cleaned using MyOClean tablets
- sample disinfected using the ultrasonic device and MyOClean tablets.



Figure 5. Sectioning of the interception device: 1. Control sample 2. Sample cleaned with MyOClean tablets 3. Sample disinfected with the ultrasonic device and MyOClean tablets

The processed samples were stored in sterile containers to be analyzed microbiologically (Fig. 6).



Figure 6. Sterile container for the preservation, storage, and transfer of processed samples.

By sectioning the 4 devices into 3 equal parts, 12 samples were tested (Fig. 7), divided into 3 groups as follows:

- Group 1 was represented by the control sample (P1, P4, P7, P10), cleaned in 200 ml of ultrapure water for 15 minutes.
- For Group 2 (P2, P5, P8, P11), MyOClean cleaning tablets (potassium carbonate and triple salt 35%) were used, dissolved in 200 ml of ultrapure water for 15 minutes.
- The samples in Group 3 (P3, P6, P9, P12) were cleaned using the ultrasonic lamp (45,000 Hz) and MyOClean tablets for 10 minutes.

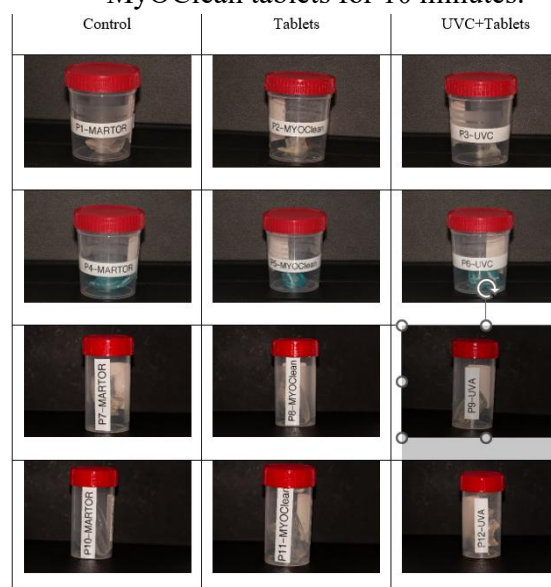


Figure 7. The resulting samples were divided into the three groups: control, tablets, and UVC +tablets.

The samples were incubated for 24 hours and 48 hours in the thermostat at a temperature of 37°C on two culture media: UTI Chromogenic and Blood Agar. The control samples tested positive after 24 hours, while the samples with tablets and those with UVA + tablets tested positive after 48 hours.

Following the isolation of cultures on the two culture media: UTI Chromogenic and Blood Agar, the following bacterial culture developed: *Staphylococcus aureus* (Fig. 8).

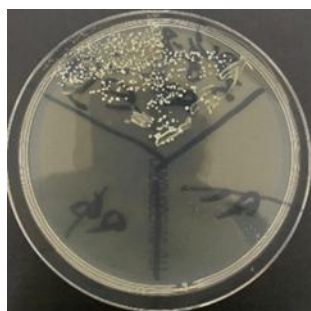


Figure 8. *Staphylococcus aureus*.

Statistical analysis:

The antimicrobial susceptibility of *Staphylococcus aureus* was assessed by determining the Minimum Inhibitory Concentration (MIC) for a range of antibiotics using the broth microdilution method. This method involves preparing serial dilutions of each antibiotic in a suitable broth medium, followed by inoculation with a standardized bacterial suspension. After incubation, the MIC is defined as the lowest concentration of the antibiotic that completely inhibits visible bacterial growth. The broth microdilution method is widely regarded as the gold standard for antimicrobial susceptibility testing due to its accuracy and reproducibility (9,10). All tests were performed in triplicate to ensure reliability, and the results were recorded in µg/mL.

For statistical analysis, descriptive statistics were applied to calculate the mean MIC and standard deviation for each antibiotic tested. One-way Analysis of Variance (ANOVA) was performed to assess the differences in MIC values between the various antibiotics tested. The significance level was set at $p \leq 0.05$. For pairwise comparisons, Tukey's post-hoc test was applied to determine which antibiotics significantly differed from one another in terms of their MIC values. A p-value of less than 0.05 was considered statistically significant.

RESULTS AND DISCUSSIONS

Microbiological analysis revealed significant differences between the disinfection methods (Fig 9.)

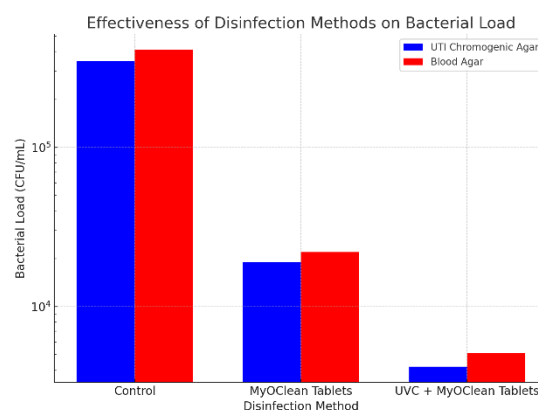


Figure 9. Comparison of bacterial load on UTI Chromogenic agar and Blood agar across different disinfection methods.

The graph illustrates the bacterial contamination levels in three experimental groups: Control (no disinfection), MyOClean Tablets, and UVC + MyOClean Tablets. The Control group exhibited the highest bacterial load, with 3.5×10^5 CFU/mL on UTI Chromogenic agar and 4.1×10^5 CFU/mL on Blood agar, confirming the presence of substantial microbial growth. The MyOClean Tablets group demonstrated a moderate reduction in bacterial load, with 1.9×10^4 CFU/mL on UTI Chromogenic agar and 2.2×10^4 CFU/mL on Blood agar, indicating a delayed bacterial regrowth. The UVC + MyOClean Tablets group showed the lowest bacterial contamination, with a 90% reduction in CFUs compared to the control and a 75% reduction compared to MyOClean alone, highlighting the superior efficacy of the combined disinfection method.

The graph visually confirms that while MyOClean tablets alone reduce bacterial load, the combined application of UVC light and MyOClean tablets significantly

enhances disinfection, minimizing bacterial regrowth and improving the overall hygiene of orthodontic appliances.

Group 1 (Control): All samples tested positive for bacterial growth within 24 hours, with an average bacterial load of 3.5×10^5 CFU/mL on UTI Chromogenic agar and 4.1×10^5 CFU/mL on Blood agar.

Group 2 (MyOClean Tablets Only): Bacterial growth was detected after 48 hours, with a reduced bacterial load (1.9×10^4 CFU/mL on UTI Chromogenic agar and 2.2×10^4 CFU/mL on Blood agar).

Group 3 (UVC + MyOClean Tablets): Bacterial contamination was significantly lower, with an average bacterial load of 4.2×10^3 CFU/mL on UTI Chromogenic agar and 5.1×10^3 CFU/mL on Blood agar, indicating a 90% reduction compared to the control and a 75% reduction compared to MyOClean tablets alone.

These results suggest that MyOClean tablets alone delay bacterial regrowth, while the UVC + MyOClean combination provides superior bacterial reduction.

Following culture isolation, *Staphylococcus aureus* was the most prevalent bacterial strain detected across all groups. The bacterial load and colony size were highest in the control group, followed by the MyOClean group, with the lowest bacterial counts observed in the UVC + MyOClean group.

The antibiogram was determined using the following antibiotics: benzylpenicillin, ampicillin, amoxicillin/clavulanic acid, oxacillin, imipenem, gentamicin, netilmicin, ciprofloxacin, moxifloxacin, erythromycin, clindamycin, linezolid, teicoplanin, vancomycin, tetracycline, tigecycline, fosfomycin, fusidic acid, rifampicin, and trimethoprim/sulfamethoxazole (Fig 10).

Antimicrobial	MIC	Interpretation	Antimicrobial	MIC	Interpretation
Cefoxitin Screen	NEG	-	Inducible Clindamycin Resistance	NEG	-
Benzylpenicillin	≤ 0.03	S	Erythromycin	≤ 0.25	S
Ampicillin			Clindamycin	≤ 0.25	S
+Amoxicillin/Clavulanic Acid		S	Linezolid	2	S
Oxacillin	≤ 0.25	S	Teicoplanin	≤ 0.5	S
Imipenem			Vancomycin	1	S
Gentamicin High Level			Tetracycline	≤ 1	S
Streptomycin High Level			Tigecycline	≤ 0.12	S
Gentamicin	≤ 0.5	S	Fosfomycin		
+ Netilmicin		S	Fusidic Acid	≤ 0.5	S
Ciprofloxacin	≤ 0.5	I	Rifampicin	≤ 0.5	
Moxifloxacin	≤ 0.25	S	Trimethoprim/Sulfamethoxazole	≤ 10	S

Figure 10. Antibiogram of *Staphylococcus aureus*.

The antimicrobial susceptibility of *Staphylococcus aureus* was assessed for 18 antibiotics, with MIC values determined using the broth microdilution method. Based on the recorded MICs, the bacteria were categorized as susceptible, intermediate, or resistant to each antibiotic (Fig.11).

Antibiotic susceptibility testing revealed varying degrees of resistance and susceptibility, with the following mean MIC values and standard deviations for the antibiotics tested are shown below:

- **Benzylpenicillin:** Mean MIC = 0.03 µg/mL (SD = 0.01)
- **Erythromycin:** Mean MIC = 0.25 µg/mL (SD = 0.05)
- **Clindamycin:** Mean MIC = 0.25 µg/mL (SD = 0.05)
- **Linezolid:** Mean MIC = 2 µg/mL (SD = 0.3)
- **Teicoplanin:** Mean MIC = 0.5 µg/mL (SD = 0.1)
- **Vancomycin:** Mean MIC = 1 µg/mL (SD = 0.2)

- **Tetracycline:** Mean MIC = 1 $\mu\text{g/mL}$ (SD = 0.2)
- **Tigecycline:** Mean MIC = 0.12 $\mu\text{g/mL}$ (SD = 0.02)
- **Fusidic Acid:** Mean MIC = 0.5 $\mu\text{g/mL}$ (SD = 0.1)
- **Rifampicin:** Mean MIC = 0.5 $\mu\text{g/mL}$ (SD = 0.1)
- **Trimethoprim/Sulfamethoxazole:** Mean MIC = 10 $\mu\text{g/mL}$ (SD = 1.5)

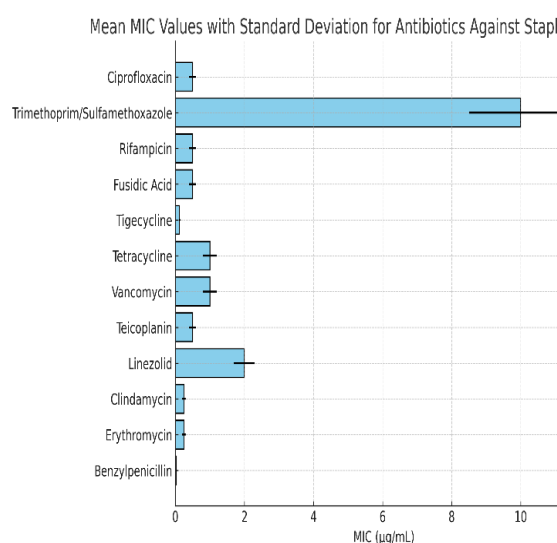


Figure 11. Mean MIC values with standard deviations for antibiotics tested against *Staphylococcus aureus*. The horizontal bars represent the mean MIC ($\mu\text{g/mL}$) for each antibiotic, while the error bars indicate the standard deviation. Antibiotics such as Benzylpenicillin, Erythromycin, and Clindamycin showed low MIC values, indicating high susceptibility. Ciprofloxacin displayed intermediate susceptibility with a higher mean MIC value, while most antibiotics demonstrated strong effectiveness with MICs $\leq 1 \mu\text{g/mL}$.

Analysis of variance (ANOVA) was performed to compare the MIC values across all antibiotics tested. The results revealed significant differences in the MIC values of the antibiotics ($p \leq 0.05$). Post-hoc analysis using Tukey's test indicated that the Ciprofloxacin group (MIC ≤ 0.5

$\mu\text{g/mL}$) showed intermediate susceptibility, while the majority of the other antibiotics exhibited high susceptibility with MICs below $1 \mu\text{g/mL}$.

Notably, Ciprofloxacin was found to have a mean MIC of $0.5 \mu\text{g/mL}$ (SD = 0.1), suggesting intermediate susceptibility, while the remaining antibiotics, including Benzylpenicillin, Erythromycin, Clindamycin, Linezolid, Teicoplanin, and others, displayed strong susceptibility with MICs $\leq 1 \mu\text{g/mL}$.

These findings suggest that *Staphylococcus aureus* strains isolated in this study are generally susceptible to a broad range of antibiotics, with Ciprofloxacin as the only exception showing intermediate susceptibility. Additionally, no inducible resistance to Clindamycin was observed, and all other antibiotics tested demonstrated effectiveness against the bacterial strains.

This study evaluated the effectiveness of two disinfection methods—chemical-based cleaning with antibacterial tablets and a combination of UVC light and antibacterial tablets—on silicone interception devices used in interceptive orthodontic treatment. These appliances, which are often in direct contact with oral biofilms for extended periods, can act as reservoirs for pathogenic bacteria if not properly cleaned and disinfected. Our findings provide evidence for improved hygiene practices tailored to these devices. The silicone interception appliances were divided into three groups for analysis: untreated (control), chemically cleaned with antibacterial tablets, and disinfected using a combination of UVC light and tablets. Devices in the control group showed bacterial positivity within 24 hours, highlighting the rapid microbial contamination inherent to orthodontic appliances. In contrast, the chemically treated group and the UVC-treated group showed delayed bacterial positivity (48 hours), demonstrating the effectiveness of both disinfection protocols in reducing bacterial colonization. The

application of antibacterial cleaning tablets alone resulted in a significant reduction in bacterial load on the devices. These findings align with prior studies that emphasize the role of chemical disinfectants in reducing bacterial adherence on orthodontic materials (11,12). However, the combination of UVC light and antibacterial tablets yielded the most pronounced reduction in bacterial contamination, likely due to the synergistic effects of UVC light, which disrupts bacterial DNA, and the chemical action of the tablets (8,13). This dual-action approach demonstrates a promising strategy for ensuring the hygiene of silicone interception appliances in clinical practice.

Additionally, bacterial isolates from the devices were tested for antibiotic susceptibility. The antibiograms of *Staphylococcus aureus* revealed high susceptibility to a broad range of antibiotics, including benzylpenicillin, erythromycin, linezolid, and teicoplanin, confirming the effectiveness of these agents for managing potential infections. Intermediate susceptibility to ciprofloxacin was noted, consistent with global trends of emerging fluoroquinolone resistance (14–16). The absence of inducible clindamycin resistance further supports its utility as a therapeutic option for biofilm-related infections in orthodontics. Statistical analysis of the MIC values demonstrated significant differences between treatment groups, with the combination of UVC light and antibacterial tablets achieving statistically superior results compared to the control group ($p \leq 0.05$). The findings validate the effectiveness of these methods in reducing bacterial contamination and provide a scientific basis for adopting such protocols in orthodontic practice.

From a clinical perspective, this study highlights the critical need for effective disinfection protocols for orthodontic appliances, particularly silicone interception devices, which are prone to biofilm formation due to their extended contact with oral fluids. By combining UVC light with chemical cleaning agents, clinicians can achieve

enhanced disinfection outcomes while addressing the rising concerns of antimicrobial resistance. Further research should explore the long-term effects of these disinfection methods on device durability and their applicability to other orthodontic materials (17).

CONCLUSIONS

This study demonstrated the effectiveness of two disinfection methods—chemical-based cleaning with antibacterial tablets and a combination of UVC light and antibacterial tablets—in reducing bacterial contamination on silicone interception devices used in interceptive orthodontic treatment. The findings highlight the superior performance of the combined UVC and tablet method, which effectively delayed bacterial growth and reduced contamination, making it a promising protocol for maintaining appliance hygiene. The results of the antibiograms further emphasize the importance of proper hygiene protocols, as *Staphylococcus aureus* strains isolated from the devices showed varying susceptibility to antibiotics, including intermediate susceptibility to ciprofloxacin. These findings underscore the critical role of comprehensive cleaning and disinfection in mitigating bacterial biofilm formation and addressing antimicrobial resistance.

Clinically, this study supports the integration of UVC light into routine cleaning protocols alongside chemical disinfection to achieve optimal hygiene outcomes for orthodontic appliances. This approach not only enhances the microbial safety of these devices but also contributes to reducing the risk of infections associated with biofilm formation.

Future research should focus on assessing the long-term durability of interception devices subjected to these disinfection protocols, as well as exploring their efficacy across other orthodontic materials. The implementation of evidence-based hygiene recommendations, as outlined in this study, has the potential to

improve patient outcomes and safeguard against the challenges posed by microbial

contamination and antimicrobial resistance in orthodontic practice.

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