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Effectiveness of Ultraviolet Light on Sterilization of Conventional Orthodontic Metal Brackets - An In-vitro study

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KEYWORDS

ultraviolet-C, sterilization, orthodontic brackets, infection control.

ABSTRACT:

Introduction: Infection control is critical in dentistry, as orthodontic appliances (brackets, wires, elastics) can harbour microorganisms that may be transmitted if not sterilized prior to use. Studies have shown that new orthodontic brackets received from manufacturers often carry bacterial contamination. Ultraviolet-C (UV-C) light with wavelength 100–280 nm is a potent germicidal method that inactivates microbes via DNA damage and offers a dry, residue-free sterilization option without heat-related warping. However, the optimal UV-C exposure time for fully sterilizing orthodontic brackets is unclear.

Objectives: To evaluate and compare the antimicrobial effectiveness of UV-C irradiation on conventional orthodontic metal brackets at exposure times of 5, 10, and 15 minutes.

Methods: Forty new, unused maxillary premolar metal brackets (0.022″ MBT prescription) were randomly assigned to four groups (n=10 each): Group 1, control (no sterilization); Group 2, UV-C exposure for 5 minutes; Group 3, UV-C exposure for 10 minutes; Group 4, UV-C exposure for 15 minutes. UV-C irradiation was applied using a bench-top UV-C sterilizer. After treatment, each bracket was aseptically placed on a blood agar plate and incubated at 37 °C for 72 hours. The primary outcome was the presence or absence of bacterial colony growth on each plate. Data was analysed with the Chi-square test (significance at $p \leq 0.05$).

Results: In the control group (no sterilization), 10 of 10 brackets (100%) showed microbial growth. After 5 minutes of UV-C, 8 of 10 brackets (80%) showed growth. After 10 minutes, 6 of 10 (60%) showed growth. After 15 minutes, only 2 of 10 brackets (20%) showed growth. The differences among groups were statistically significant (Chi-square $p < 0.001$). Increasing UV-C exposure time correlated with a marked reduction in bacterial contamination.

Conclusions: UV-C irradiation significantly reduced microbial load on orthodontic metal brackets in vitro in a time-dependent manner. Fifteen minutes of UV-C exposure achieved the greatest sterilization. These results support UV-C as a rapid, heat-free method for disinfecting orthodontic

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brackets prior to clinical use.

1. Introduction

Effective sterilization of orthodontic appliances is essential to prevent cross-transmission of pathogens in dental practice.[1] Previous studies have demonstrated that new orthodontic appliances supplied by manufacturers often harbours bacteria such as Staphylococcus aureus, S. epidermidis, Lactobacillus spp., Klebsiella pneumoniae, and others.[2,3,4,5] Failure to sterilize these brackets before bonding could introduce infection.[6,7] According to infection-control guidelines, dental instruments can be sterilized by methods such as steam autoclaving or dry heat, and chemical disinfectants or UV radiation may also be used for disinfection.[8,9,10]

Ultraviolet-C radiation (100–280 nm) falls within the germicidal UV range and is commonly employed in clinical sterilization applications. The germicidal effect of UV-C arises from photochemical damage to microbial DNA and RNA (such as thymine dimer formation), which inactivates pathogens. Because UV-C disinfection does not involve chemicals or high heat, it leaves no harmful residue and minimizes thermal stress or corrosion on metal instruments.[8,11] Previous studies in orthodontics have shown UV-C can effectively disinfect instruments e.g. orthodontic pliers[11] and is recommended for sterilizing appliances before clinical use.[2] However, reported effective exposure times vary widely, from seconds to many minutes, and the optimal duration for sterilizing orthodontic brackets remains uncertain.

The purpose of this in vitro investigation was to evaluate the impact of different UV-C irradiation times on the microbial decontamination of conventional orthodontic metal brackets. We tested the null hypothesis that UV-C exposure at these times would not reduce bacterial contamination compared to unsterilized controls.

2. Objectives

1. To evaluate the microbial growth around orthodontic metal brackets without any sterilization (Control group).
2. To evaluate the microbial growth around orthodontic metal brackets after exposure to UV rays for 5, 10 and 15 min.
3. To compare the microbial growth around orthodontic metal brackets after exposure to UV rays for 5, 10 and 15 min.

3. Methods

This laboratory study used 40 brand-new orthodontic metal premolar brackets (0.022″ slot MBT prescription), all from the same manufacturer. Brackets were handled with sterile forceps and randomly divided into four groups (n = 10 each). Group 1 (control) received no sterilization treatment. Groups 2–4 were each exposed to UV-C light for a specified duration: 5, 10, or 15 minutes respectively. UV-C irradiation was delivered using a UV-C sterilizer. Brackets were placed equidistant from the UV-C lamp surface, ensuring uniform exposure.

Immediately after the exposure, each bracket was aseptically transferred onto the centre of a sterile blood agar plate. Plates were incubated at 37 °C for 72 hours under aerobic conditions to allow any bacteria to form visible colonies. After incubation, plates were examined for growth; each bracket's result was recorded simply as "growth" (one or more colonies present) or "no growth."

Data were entered into SPSS v.24 for analysis. A Chi-square test compared the proportion of contaminated brackets across groups. The significance level was set at $p \leq 0.05$.

4. Results

In the unsterilized control group, all 10 brackets (100%) demonstrated bacterial colony growth on the agar plates (Table1, Graph 1). In the UV-C treated groups, contamination was progressively reduced with longer exposure times. After 5 minutes of UV-C, 8 of 10 brackets (80%) still showed growth (Table2, Graph 2); after 10 minutes, 6 of 10 (60%) showed growth (Table3, Graph 3); after 15 minutes, only 2 of 10 (20%) showed growth (Table4, Graph 4). None of the UV-C–treated groups achieved 100% sterility, but the trend was clear. Statistical analysis (Chi-square) indicated a highly significant difference among the four groups ($p < 0.001$), rejecting the null hypothesis that UV-C exposure had no effect.

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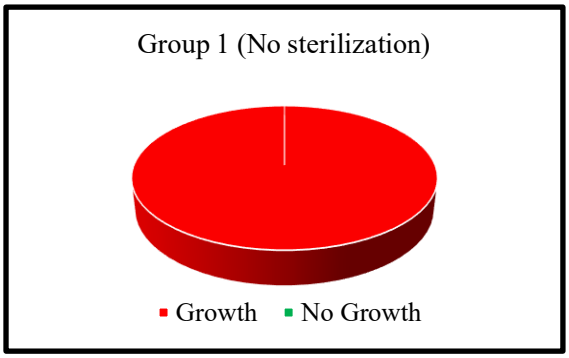
Table 1. Distribution of growth in Group 1

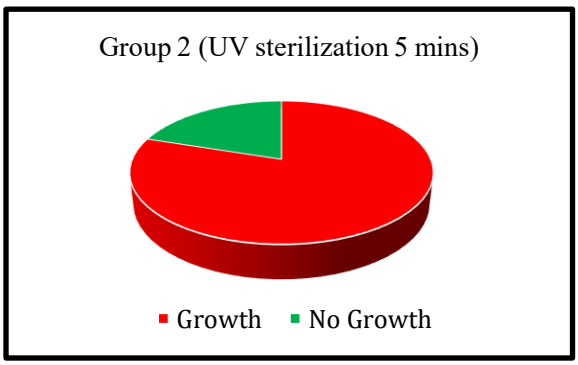
Group		Growth	No Growth
Group 1 (No sterilization)	N	10	0
	%	100%	0%



Graph 1. Distribution of growth in Group 1

Table 2. Distribution of growth in Group 2

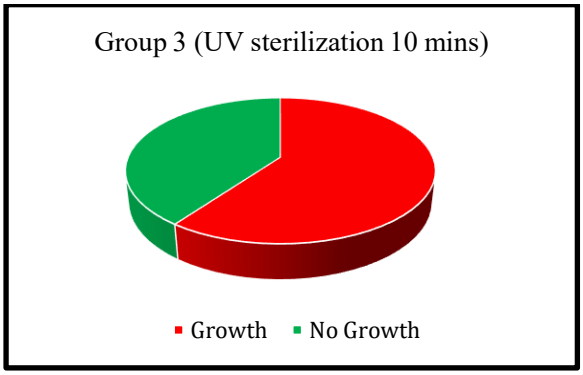
Group		Growth	No Growth
Group 2 (UV sterilization 5 mins)	N	8	2
	%	80%	20%



Graph 2. Distribution of growth in Group 2

Table 3. Distribution of growth in Group 3

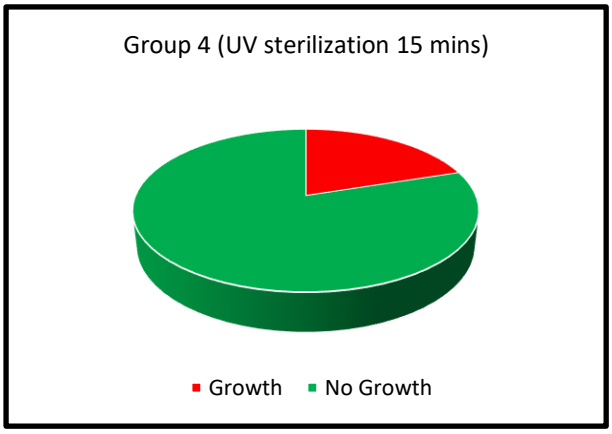
Group		Growth	No Growth
Group 3 (UV sterilization 10 mins)	N	6	4
	%	60%	40%



Graph 3. Distribution of growth in Group 3

Table 4. Distribution of growth in Group 4

Group		Growth	No Growth
Group 4 (UV sterilization 15 mins)	N	2	8
	%	20%	80%



Graph 4. Distribution of growth in Group 4

5. Discussion

Studies have found bacteria on orthodontic appliances straight out of the manufacturer's packaging including Staphylococcus aureus, Staphylococcus epidermidis, Lactobacillus species, and Klebsiella pneumoniae.[2,3,4,5] If the brackets are not sterilized before placement, they may introduce infection into the oral cavity during bonding procedures.

The findings indicate that UV-C irradiation markedly decreases microbial contamination on conventional orthodontic brackets under laboratory conditions and that disinfection efficacy improves with longer exposure time. These results align with previous findings that

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orthodontic brackets and other appliances often arrive contaminated and require sterilization. For example, Aithal et al.[9] reported that new brackets from multiple manufacturers exhibited high rates of bacterial contamination (including S. aureus, S. epidermidis, Lactobacillus, Klebsiella, and Bacillus species). Our control brackets similarly showed universal growth (100%).

Our findings also support the value of UV-C as an alternative sterilization method. Ardeshna et al.[2] have noted that UV light can effectively disinfect orthodontic appliances without altering material properties and is recommended prior to clinical placement. In line with this, we found that UV-C could rapidly eliminate most culturable bacteria from bracket surfaces without using heat. UV-C sterilization is appealing because it is a dry, residue-free technique that avoids corrosion or heat-induced deformation of orthodontic instruments.[2,12] In practice, ensuring no heat or moisture means brackets retain their integrity and corrosion resistance even after treatment.

Comparative studies in dentistry have demonstrated UV-C efficacy on various objects. Moufti et al.[12] showed that properly designed UV-C cabinets can achieve high-level disinfection of dental devices. Lucas et al.[11] found UV-C effective for orthodontic pliers, again emphasizing UV's practicality for orthodontic instruments. Our results extend these observations to bracket sterilization. The dose-dependent improvement we observed – from 80% sterility at 5 min to 100% in only 2 of 10 brackets at 15 min – indicates that "twice as long" UV-C had markedly better effect. This suggests a relatively steep kill curve, although even 15 min did not sterilize all brackets fully.

The observed lack of complete sterilization at shorter UV-C exposure times could be due to factors like insufficient dose or uneven exposure. Complex bracket shapes can produce shadowed regions that UV-C light may not hit directly. Thus, some bacteria might be shielded if not in direct line-of-sight of the lamp. Also, we measured only visible colony-forming units; highly resistant spores or viruses (which UV-C can kill at sufficient doses) were not assessed. Our outcomes suggest that a 15-minute UV-C cycle is likely to eliminate the vast majority of common bacteria on these brackets but may require validation against more resistant organisms.

The study's limitations include its in vitro design and single bracket type. Only one bracket design (0.022″ MBT premolar bracket) was tested, so results might vary for other bracket shapes or materials. In clinical practice, brackets could be bonded with minimal pre-cleaning, so any sterilization method should account for the full spectrum of microbes in the oral environment. We only tested aerobic bacterial growth; anaerobes, viruses, and fungal spores were not evaluated. In addition, our sample size was modest (10 per group), although the strong significance suggests the effect is robust.

Overall, this study demonstrates that UV-C irradiation is a rapid and effective method for reducing microbial contamination on orthodontic brackets. Since UV-C is dry and residue-free, it avoids the need for chemical rinses or high heat that could damage brackets. In practice, a 10–15-minute UV-C cycle could serve as a convenient chairside sterilization step for brackets before bonding. Determining the minimal effective exposure time that balances efficacy with clinical efficiency is an important next step. Standardizing such UV protocols could improve infection-control practices in orthodontic clinics.

6. Conclusion

Ultraviolet-C (UV-C) irradiation significantly reduced bacterial contamination on conventional orthodontic metal brackets in vitro. These findings support the use of UV-C as a practical, heat-free method for sterilizing brackets prior to clinical use. Standardization of UV-C sterilization protocols may enhance infection control in orthodontic practice.

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