Title:	Infection Control Dilemmas Regarding the Use of Polytetrafluorethylene Tape in Dentistry
Type of article:	Research
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Abstract:

Introduction:

The widespread use of Polytetrafluoroethylene (PTFE) tape in clinical practice is surrounded by uncertainty regarding bacterial growth and contamination. PTFE tape is not manufactured, distributed or stored with the purpose of being used in a dental clinical setting and since it is not currently identified as a dental material, the production line and storage protocols do not ensure the sterility of the final product.

Aims:

The aim of this small-scale preliminary study was to investigate whether PTFE tapes are microbially contaminated, following distribution and prior to application in dental clinical settings.

Materials and Methods:

11 tapes were microbiologically investigated using two separate methods and were incubated both aerobically and anaerobically. Gram staining was performed for all identifiable colonies.

Results:

All PTFE tapes were contaminated with microbes, but an uneven distribution of contaminants was observed within each PTFE tape reel. The PTFE tape samples were mainly contaminated with environmental spore-forming bacteria, namely *Bacillus licheniformis, Bacillus amyloliquefaciens ssp. Plantarum, Bacillus amyloliquefaciens* and *Aneurinibacillus migulanus*.

Discussion and Conclusion:

This preliminary work highlights an area of clinical concern and raises awareness regarding the contamination of PTFE tapes used in dental clinical settings. It also highlights the importance of designing a standardised sterilisation protocol for PTFE tapes in order to ensure that the material is free of bacterial contaminants prior to application.

Keywords: Polytetrafluoroethylene tape, PTFE tapes, dental microbial contamination, dental clinical practice.

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Introduction

The successful integration of innovative techniques, combined with the introduction of unconventional materials into the constantly evolving field of prosthodontics, has contributed to the incorporation of polytetrafluorethylene (PTFE) tape in the dental armamentarium. PTFE tape is beneficial in a plethora of clinical applications on account of its numerous advantageous physical and chemical properties.

PTFE tape has a valuable ease of manipulation and handling properties, which are key in allowing it to be an effective tool in the atraumatic retrievability of restorations. Its hydrophobicity arises from the high electronegativity of fluorine, which allows the material to demonstrate strong dispersion forces, thus preventing the wetting of PTFE tape by water and water-containing substances.[1] The high melt viscosity of this material prevents its degradation at high temperatures, whilst its non-filamentous structure allows easy removal without residue following its application.[2] Adding PTFE tape to a dental instrument increases the static contact angle from 40° to 70°, thus allowing easier handling of the dental material and preventing void formation during material processing. However, autoclaving the PTFE tape prior to application has been reported to reduce the contact angle to 50°, thus resulting in deterioration of its non-stick properties.[3] Bacterial colonisation and microleakage have been observed in conjunction with the use of PTFE tape, as a variety of physical and chemical parameters are potentially influencing biofilm formation and bacterial adherence to the material, whilst increased surface roughness has been suggested as an underlying contributing factor.[4]

Despite those beneficial characteristics, uncertainty remains regarding bacterial growth and contamination relating to this material. It is imperative to highlight that a number of protocols are set out by regulatory organisations for infection control in clinical practice. These emphasise the importance of using decontaminated materials to prevent penetration of oral tissues by microorganisms with pathogenic potential. However, considering that PTFE tapes, also known as ‘plumber’s tapes’, are not produced by companies that identify themselves as manufacturers of dental or clinical equipment, the production line and storage protocols do not ensure the sterility of the final product. Therefore, the possibility that there are microbial contaminants on the material should be considered and further investigated.

Materials and Methods

For this preliminary work, as an initial stage of a PTFE microbial contamination approval study, 23 PTFE tapes were identified in the UK market with the potential for application in dentistry. A sample of 11 tapes was randomly selected; the criteria for the sample size selection were 90% confidence interval, 19% margin of error and 50% population proportion. The PTFE tapes were obtained from online platforms. This decision was made on the basis that clinicians often order their selected PTFE tapes from online market platforms, as dental suppliers do not provide PTFE tapes. All tapes were 12mm wide, except for tape with identification number 3, which was 18mm wide.

Samples obtained from the 11 tapes were microbiologically investigated using two separate methods and were incubated both aerobically and anaerobically. Gram staining was performed for all identifiable colonies.

Method 1

Adopting an aseptic technique, a 7cm strip of each PTFE tape was placed on agar plates composed of CM0271 Blood Agar Base No.2 (Oxoid Ltd., Basingstoke Hampshire, UK) and HB034 6% defibrinated horse blood (TCS Biosciences Ltd., Botolph Claydon Buckingham, UK).

Test 1: The strip was placed flat on surface and turned over after 15 seconds. The strip was then left in place for a 72h incubation at 37 °C in a 5% CO_2 atmosphere.

Test 2: The strip was placed flat on surface and incubated for 24h at 37°C in a 5% CO_2 atmosphere. The strip was then turned over and left in place for a 48h incubation at 37°C in a 5% CO_2 atmosphere.

The method described for 'Test 2' was also followed for a 120h anaerobic incubation in 10% hydrogen, 10% CO_2 and 80% nitrogen. Accuracy protocols were applied, and no error was detected.

Method 2

In order to collect quantitative data (colony counts) to be expressed in terms of colony-forming units, this second method was applied.

Adopting an aseptic technique, a 15cm strip of each PTFE tape was folded and inserted into separate containers with a 5ml CM1135 Brain Heart Infusion solution (Oxoid Ltd., Basingstoke Hampshire, UK) and 20 glass beads of 4mm diameter (Merck Millipore, Watford Hertfordshire, UK). The solution was agitated on a rotary stirrer for 1 minute and 100µl were spread on agar plates [CM0271 Blood Agar Base No.2 (Oxoid Ltd., Basingstoke Hampshire, UK) and HB034 6% defibrinated horse blood (TCS Biosciences Ltd., Botolph Claydon Buckingham, UK)]. The spread plate was incubated for 72 h at 37°C in a 5% CO_2 atmosphere.

The same method was also followed for a 120h anaerobic incubation in 10% hydrogen, 10% CO_2 and 80% nitrogen. Accuracy protocols were applied, and no error was detected.

Data Collection

All data was collected following the completion of a 72h aerobic or a 120h anaerobic incubation in the Blizard Institute at Barts and The London School of Medicine and Dentistry at Queen Mary University.

All qualitative descriptions and numerical counts were decided upon following assessment undertaken by two individuals.

Qualitative data regarding all identifiable colonies was collected for both aerobically and anaerobically cultured colonies. The level of contamination was also qualitatively assessed and assigned one of four descriptions 'none, low, medium, heavy' following independent visual inspection by two individuals.

The number of colonies was recorded for each PTFE tape sample from its respective spread plate. Differential colony counts were carried out where appropriate; different colony types were discriminated by colony morphology traits. The levels of total contamination were determined quantitatively by the colony counts obtained via 'Method 2' and the data was expressed as colony forming units (cfu) per cm^2. The detection limit was set at 1 cfu per $100cm^2$.

MALDI-TOF Identification

A number of colonies were sub-cultured, and samples were obtained for identification. The colonies that were sampled for identification were randomly chosen. For bacterial identification, Matrix Assisted Laser Desorption Ionization – Time of Flight (MALDI-TOF) Mass Spectrometry was carried out, using a MALDI Biotyper (Bruker, Coventry, UK). A score value of ≥ 2.0 was calculated, which is considered acceptable for species level identification.

Results

The results of this preliminary study demonstrated that:

- All PTFE tapes were contaminated with microbes upon receipt.
- Dissimilar levels of contamination between PTFE tapes from different manufacturers were detected (Graph 1).
- The microbial contamination within each tape is of uneven distribution; different types and number of colonies were detected on different strips from the same PTFE tape reel (Table 1).
- Low levels of anaerobically cultured colonies were obtained relative to aerobically cultured colonies (Table 1).
- Gram-positive species are more prevalent than gram-negative species (Graph 2).
- Gram-positive rods are most abundant, followed by gram-positive cocci. Low numbers of gram-negative rods were identified in one PTFE tape and no gram-negative cocci were isolated from any of the samples. No gram-variable bacteria were identified (Graph 2).
- Identification tests using MALDI-TOF revealed *Bacillus licheniformis* (aerobic and anaerobic), *Bacillus amyloliquefaciens ssp. Plantarum, Bacillus amyloliquefaciens* and *Aneurinibacillus migulanus* to be present on the PTFE tapes that were sampled.

Control photographs were taken at every stage of the investigation in order to maintain an accurate record of the collected data (Figures 1-4).

Discussion

This small-scale preliminary study has the purpose of raising awareness of the contaminated PTFE tapes currently used during the delivery of dental treatment and aims to encourage further research into this minimally investigated aspect of PTFE tape application in dentistry. The data collected is limited, yet representative of the inconsistent contamination of PTFE tapes.

Following identification testing using MALDI-TOF, we can conclude that no strict anaerobes were present in our sample, only facultatively anaerobic species in addition to aerobic species. However,

the limitations of this preliminary study should be taken into consideration, as not all colonies were sampled for microorganism identification due to time and equipment limitations.

The results of this investigation revealed that the PTFE tapes are inconsistently contaminated with environmental spore-forming bacteria. *Bacillus licheniformis* was isolated from both aerobically and anaerobically cultured colonies; it is recognised as a human pathogen of environmental origin, associated with infections, particularly in immunocompromised patients, and isolated from patients with peritonitis, endocarditis, food poisoning, eye infections and bacteraemia.[5] High mortality and morbidity have been observed in patients with haematological malignancies, infected with *Bacillus spp*.[6] Other identified microorganisms include *Aneurinibacillus migulanus* and *Bacillus amyloliquefaciens*, which are soil-borne bacteria. Neither is recognised as a human pathogen, but there is concern regarding the latter's potential as an opportunistic pathogen in immunocompromised and critically ill patients. Furthermore, neonatal bacteraemia in two preterm neonates, caused by *Bacillus amyloliquefaciens,* has also been reported and documented.[7] Therefore, considering that opportunistic pathogens were isolated from aerobically and anaerobically incubated PTFE tape samples, it is important to ensure that PTFE tapes are free of microbial contamination prior to application.

Despite the limitations of this investigation, the results highlight an area of clinical concern that needs to be further investigated in order to improve the healthcare services and the quality of treatment offered to patients, with respect to the dental materials they are being exposed to.

Conclusion

Dental materials and equipment currently utilised in healthcare settings are provided by healthcare suppliers and manufacturers, unlike PTFE tape which is not currently recognised as a dental material. The use of PTFE tape can be of significant advantage to clinicians, yet its potential unsuitability due to microbial contamination must be further evaluated and researched. Further study should be undertaken in order to investigate how microbial contamination can be eliminated from the PTFE tapes prior to clinical use. This would optimise infection control by adhering to protocols, such as ensuring that all equipment has been adequately disinfected and sterilised prior to patient use. Therefore, this preliminary study highlights the importance of designing a standardised sterilisation protocol for PTFE tapes, which will not deteriorate the material's physical properties and compromise its effectiveness.

Declaration of interests

None.

Acknowledgments

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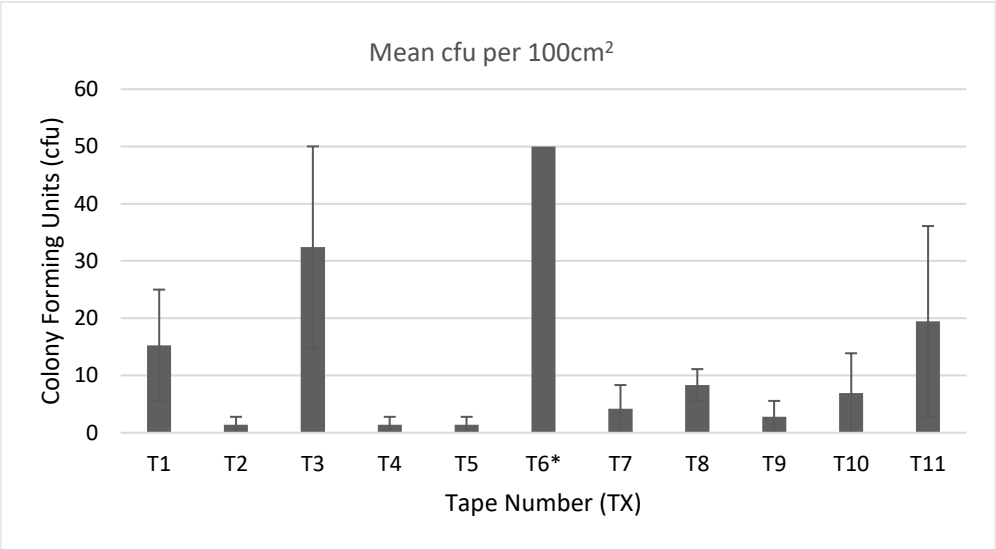
Appendix:

Table 1 – Total colony counts and qualitative distribution of total levels of contamination.

∞ represents an 'infinite' number of colonies; too many to accurately count.

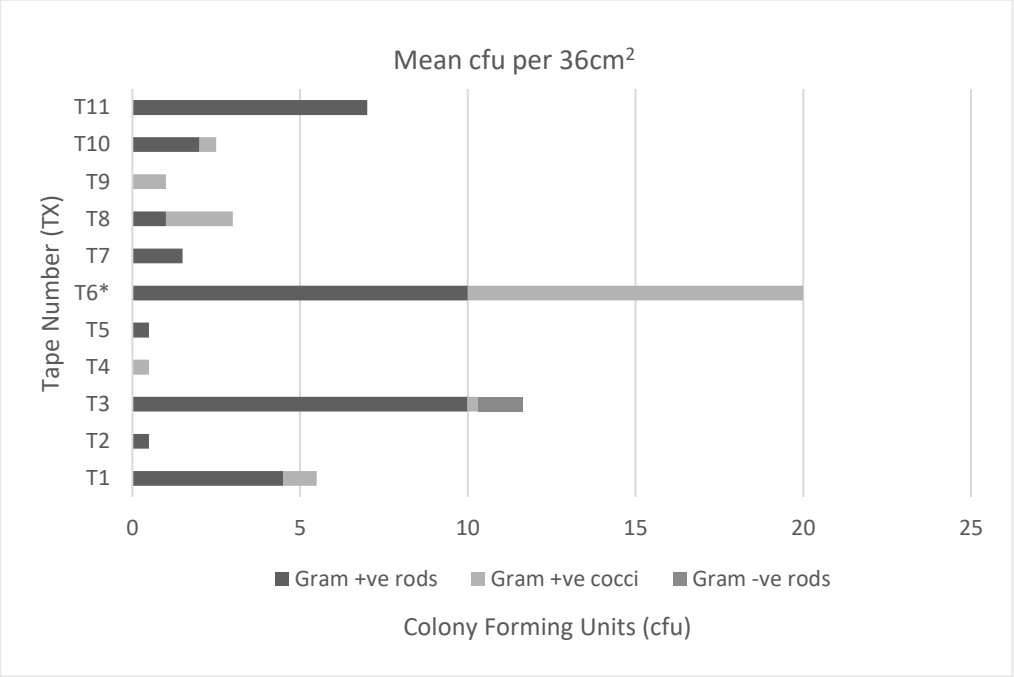
Tape ID Number (TX)	'Method 1' – Level of contamination			'Method 2' – Total Number of Colonies		
	'Test 1' 72 h Aerobic Incubation	'Test 2' 72 h Aerobic Incubation	120 h Anaerobic Incubation	'Test 1' 72 h Aerobic Incubation	'Test 2' 72h Aerobic Incubation	120 h Anaerobic Incubation
T1	Low	Heavy	Medium	2	9	0
T2	None	Heavy	Medium	0	1	5
T3	Heavy	Heavy	Medium	8	27	7
T4	Heavy	Heavy	Medium	1	0	6
T5	Medium	Heavy	Medium	0	1	6
T6	Heavy	Low	Medium	∞	5	8
T7	Low	Heavy	Medium	0	3	1
T8	Low	Heavy	Medium	4	2	5
T9	None	Heavy	Medium	2	0	2
T10	Heavy	Heavy	Medium	5	0	144
T11	Heavy	Heavy	Medium	13	1	5

Graph 1 – Degree of total bacterial contamination following 72 h aerobic incubation, expressed as colony-forming units.



*'infinite' number of colonies for 'testl 1', and thus unable to draw error bar – arbitrary value assigned = 50 cfu

Graph 2 – Distribution of gram-positive and gram-negative, rods and cocci, following 72 h aerobic incubation, expressed as colony-forming units.



*'infinite' number of colonies for 'test 1'' – arbitrary value assigned for gram +ve rods and gram +ve cocci = 10 cfu

Figure 1 – Tape ID number 11; 'Test 1' 72 h Aerobic incubation, photographic evidence of data obtained by 'Method 1' seen on the Left and 'Method 2' seen on the Right.

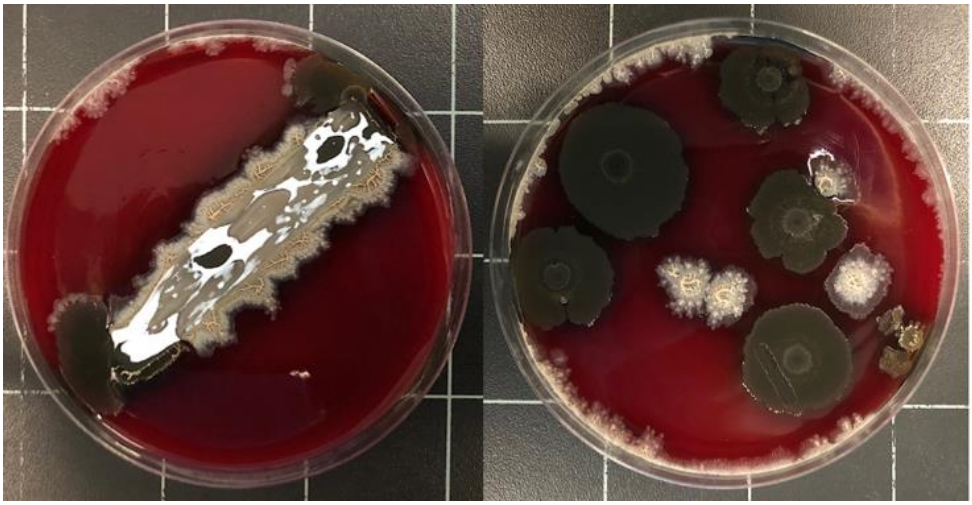


Figure 2 – Tape ID number 6; 'Test 1' 72 h Aerobic incubation, photographic evidence of data obtained by 'Method 1' seen on the Left and 'Method 2' seen on the Right.

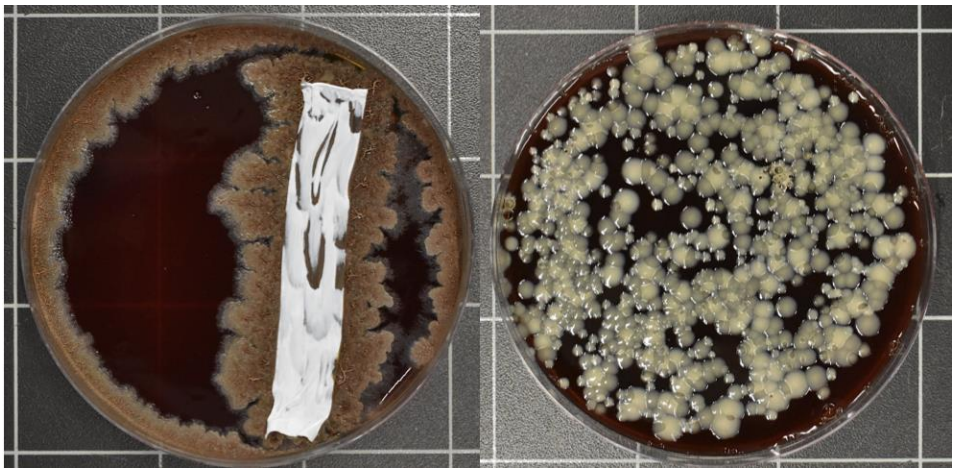


Figure 3 – Tape ID number 3; 'Testl 2' 72 h Aerobic incubation, photographic evidence of data obtained by 'Method 1' seen on the Left and 'Method 2' seen on the Right.

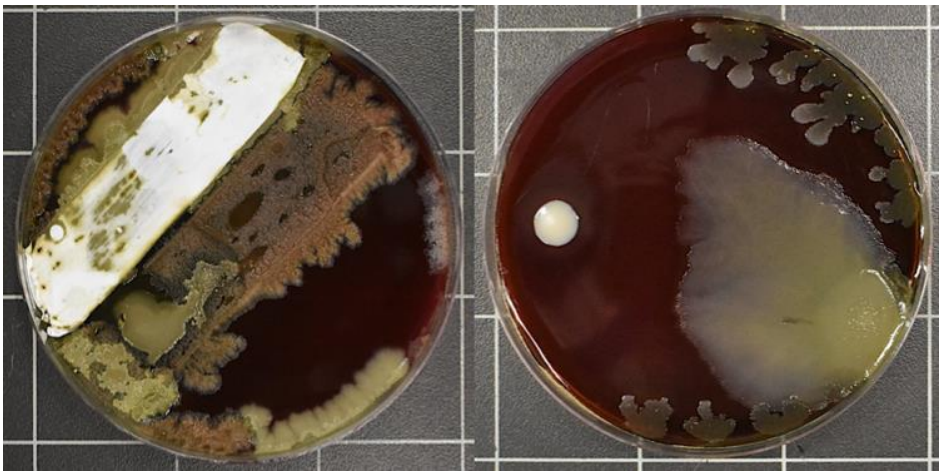
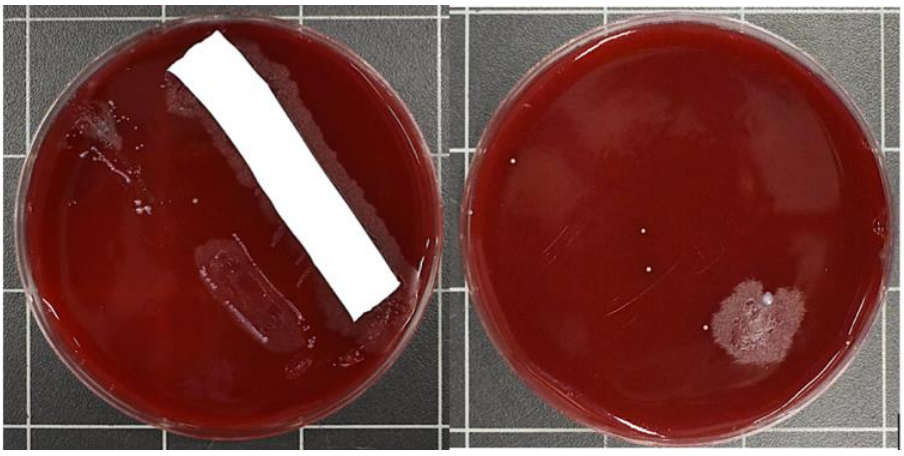


Figure 4 – Tape ID number 6; 72 h Anaerobic incubation, photographic evidence of data obtained by 'Method 1' seen on the Left and 'Method 2' seen on the Right.



Abbreviations:

cfu	Colony Forming Units
CM0271	Culture Media number 0271
h	Hour
Ltd	Limited Company
MALDI-TOF	Matrix Assisted Laser Desorption Ionization – Time of Flight
PTFE	Polytetrafluoroethylene
UK	United Kingdom
+ve	Positive
-ve	Negative