Evaluation of Microplastics Generation During Simulated Toothbrushing

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Background

Microplastics, increasingly recognized for their environmental persistence and potential health implications, are of particular concern in the pediatric population due to heightened susceptibility to endocrine-disrupting chemicals (EDCs). Routine toothbrushing has been identified as a possible source of microplastics generation, raising concerns regarding ingestion and absorption. This pilot study investigates the extent of microplastics release during simulated toothbrushing on human extracted teeth under controlled conditions.

Objectives

This pilot study aims to investigate microplastic particles released during simulated toothbrushing on extracted human molars. By employing a calibrated mechanical brushing simulator, the study seeks to assess the extent of microplastic generation, with a particular focus on plastics associated with endocrine-disrupting chemical (EDC) activity.

Methods

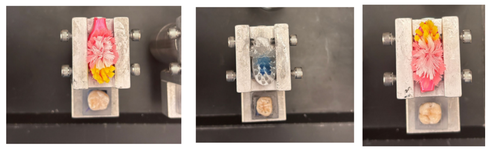
A calibrated mechanical brushing simulator was used to replicate one year of brushing under controlled force and speed. Water samples collected before and after brushing were filtered to isolate microplastic particles, which were subsequently characterized through advanced microscopic and spectroscopic techniques to determine particle size, morphology, and chemical composition, with a specific focus on plastics associated with endocrine-disrupting chemical (EDC) activity.

Tooth brush placement in holder for toothbrushing machine prior to simulated brushing cycles.

Mounted weighted sample, simulating brushing force, with toothbrush attached, and intact molar.

Methods

Tooth brushing machine with the brush attachments moving back and forth, and the sample cups (occlusal surface) rotate



Images show toothbrush head samples after going through simulated brushing cycle (shown on right)

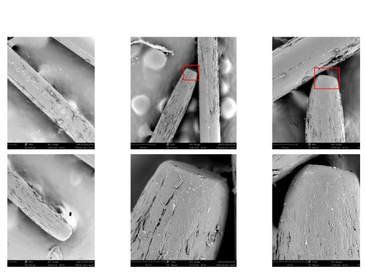
Brushing Samples: The substrates selected for this pilot study consisted of human enamel, specifically non-carious, intact molars. Selected molars have mesial to distal occlusal table length of 10mm ± 1mm, and a buccal to lingual width of 9mm ± 1mm, measured using an electronic caliper for precision. Each sample was prepared by making a straight cut at the cemento-enamel junction (CEJ). Once cut, the samples were polished using an electronic polishing machine with 800 grit silicon carbide paper at a speed of 300 rpm under cooling water, to ensure a flat smooth surface. Each finished sample was then attached to a 3D printed mounting table (dimensions of 10x10x5mm) via medium body to attach to the brushing apparatus. A total of 8 teeth were utilized in this pilot study.

Brushing Simulation: To simulate brushing, a mechanical brushing simulator was used so that the number of cycles, force, and speed were all controlled. The simulation involves 10,000 brushing cycles, representing one year of daily brushing. Each brushing cycle will consist of standardized forward-backward strokes at a speed of 90 rpm, while the occlusal surface of the teeth will rotate at 2 rpm. The force applied during each brushing cycle will be 2.45N, equivalent to 250 grams of weight.

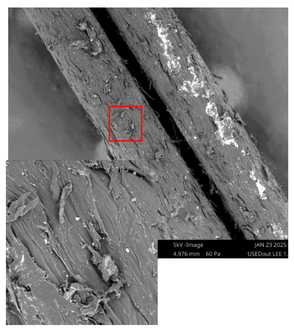
Duration: The entire simulation will last approximately 4 hours, with each sample undergoing 10,000 cycles to complete the test equating to 1 year of brushing.

Sample Collection for Microplastics Analysis: After completing the brushing cycle, each tooth sample's occlusal surface and its corresponding brush head were each thoroughly rinsed with 10mL of DI water. The rinse was directly collected into their respective glass vials, ensuring no cross contamination between samples

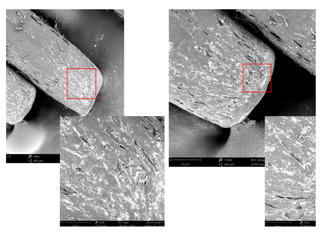
Results



SEM images of unused controlled bristles



SEM images of used bristles



SEM images of tips of used bristles

This pilot study provides evidence of visible toothbrush bristle degradation, suggesting potential microplastic release. While the exact quantity of microplastics has not yet been determined, clear signs of bristle wear were observed.

Discussion

Our pilot study examined toothbrush bristle wear over time using electron microscopy (EM) imaging. Analysis of eight samples revealed visible bristle degradation when comparing used and unused toothbrushes. While microplastics quantification was not conducted in this phase, subsequent samples underwent 10,000 brushing cycles (simulating one year of use) before being rinsed with deionized water to collect potential microplastics particles. The rinsate—including generation of particles from the tooth, 3D-printed mounting table, and toothbrush—was stored in individual glass vials for further analysis. These vials have been sent for additional evaluation which includes Fourier-Transform Infrared Spectroscopy (FITR) and results are pending.

Conclusion

The findings of this study aim to delineate the extent of microplastic exposure associated with routine toothbrushing. These insights could inform the development of safer oral care products designed to minimize microplastic release, particularly for pediatric populations, thereby mitigating the risks associated with endocrine-disrupting chemical (EDC) exposure and related health concerns.

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