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FEASIBILITY STUDY ON THE DETECTION OF AIRBORNE PARTICULATES IN A DENTAL SURGERY USING AN OPTICAL PARTICLE COUNTER

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Feasibility study on the detection of airborne particulates in a dental surgery using an optical particle counter

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Approved on behalf of NPLML by
Dr Richard Brown, Head of Metrology.

EXECUTIVE SUMMARY

From 8 June 2020, general dental practices and community dental services in England were permitted to resume face-to-face routine and urgent care for appropriate patient groups. This followed a period of pause (from 26 March) on routine treatments during the height of the COVID-19 Pandemic.

The resumption of services included the delivery of both Aerosol Generating Procedures (AGPs) and non-AGP activities. There was a requirement that this care be delivered in accordance with appropriate infection control and PPE requirements as set out in a revised Standard Operating Procedure (SOP) published by the Office of the Chief Dental Officer and NHS England on 8 June 2020 (version 2) for dental practices to support the resumption of the full range of dental provision safely.

In the same month, Clinical Directors at the MyDentist group approached the National Physical Laboratory (NPL) to undertake a feasibility study looking at AGPs, and the associated monitoring and measurement (in real time) of aerosol particle concentration in a room (clinical space) during actual patient treatment.

Scientists at NPL conducted a preliminary investigation at a MyDentist surgery using an Optical Particle Counter (OPC) to assess the airborne particle number concentrations present and how they are affected by different AGPs. Current Dental procedures and associated guidance is based on a number of assumptions linked to air quality in each clinical setting. One aim of this study was to gauge particle removal times in a real-world dental surgery seeing patients - highly relevant for informing ‘fallow’ times between patients.

The study involved an examination of the suitability of an exemplar commercially available instrument – an Optical Particle Counter (OPC) to measure airborne particle number concentrations, to determine background concentrations, the duration of elevated episodes, and to explore differences in detection of aerosols from different AGPs across different times of the day in adult patients. A suite of mitigation processes were put in place during testing, including high volume suction with wide bore aspiration tips.

Key Findings:

The study suggested that **in the particular clinical environment used, the particulate concentrations were driven by ambient background effects and non-AGP activities.** A full list of key findings and conclusions from this study are set out in the main body of the report below, however:

- The study suggested that even in a small clinical space, the impact from the range of 41 AGPs applied, when used with mitigation procedures, on room aerosol concentrations was limited.

- The initial evidence suggests that airborne particle concentrations in the measured size range (0.2 - 10 µm) were mostly driven by ambient background effects or non-AGP activities in the vicinity.

- Based on this feasibility study, regardless of the source of the peaks in the OPC data, the duration of these events did not exceed 20 minutes. The mean event duration time was approximately 10 minutes.

Summary of Recommendations

The findings from this real-world feasibility study with patients provides a first step to better understanding the impact on particle concentrations of dental treatments that require various types of AGP. However, the scale and scope of this study was limited e.g. in one clinical area and a single fixed point OPC. Therefore, it is recommended that the results of this study can be used to **inform the planning of a more detailed study with more sampling points (including windowless rooms), instruments and targeted sampling of AGPs.** It is further recommended:

i. That these findings be shared, in the first instance with members of the Scottish Dental Clinical Effectiveness Programme (SD CEP), and the Office of the Chief Dental Officer for England.

ii. That an application for a short term (20 day) Measurement for Recovery (M4R) grant be made in order to undertake some small scale testing in other clinical settings and to allow for further analysis and reporting of data taken from a Condensation Particle Counter (CPC), also used during the feasibility study.

iii. That an in-depth, larger scale, follow on study is conducted to build on these findings to include the testing and validation of multiple OPC instruments from across the sensitivity and cost spectrum to better capture the concentration of airborne particles in dental surgeries during AGP procedures.

CONTENTS

1 AIM

This was a preliminary investigation (feasibility study) conducted at a MyDentist surgery in a live (operational) clinical environment with patients, using an Optical Particle Counter (OPC) to assess the airborne particle number concentrations present and how they are affected by Aerosol Generating Procedures (AGPs) with real-world mitigation processes in place.

The aim of this feasibility study was to gauge particle removal times, which will be relevant for fallow times between patients, to examine the suitability of an exemplar commercially available instrument to measure airborne particle number concentrations, to determine background concentrations and to explore differences in detection of aerosols from different AGPs. As only a single OPC was used at a fixed point within the surgery, final conclusions must not be drawn from this study in isolation.

2 EQUIPMENT AND EXPERIMENTAL SET UP

2.1 EQUIPMENT

The equipment used in this study was:

- Optical Particle Counter
  - PALAS Promo 2000 P using a WELAS 2100 P head
  - Particle size range of 0.2 µm - 10 µm
  - Instrument calibration was conducted at setup using the PALAS reference material and procedure

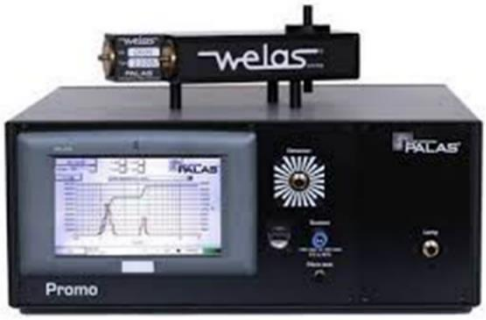

Figure 1 – PALAS Optical Particle Counter

The broad size range of particles detected by the OPC was suitable for an initial feasibility study as it covered both the sub-micron and micron ranges thought to be relevant to COVID-19 transmission.

2.2 MITIGATION MEASURES

The key mitigation measures in place were:

- Wide bore (11mm and 16 mm) aspiration tips
  - Engineering tests have been conducted that showed significant improvement on the suction capability when using 16 mm aspirator tips compared to the

standard 10/11 mm aspirator tips commonly used;

- High volume suction at 300 L min^{-1}
  - This was assessed prior to this study by a dental engineer using a Suction Capability Test to ensure that units were running at or above the required 300 L min^{-1};

- Four-handed dentistry
  - dentistry working with dental assistant /nurse;

- Use of rubber dam as a physical barrier for many of the procedures with AGPs;

- Air filtration Unit
  - This was used on its automatic filtration setting (not the high flow setting) from 14:00 on the 13th July.

	Clean Dental via UKDentech/Medimatch Collaboration
CADR	410 m^3 hr^{-1}
FILTER	HEPA
UV	Yes

Table 1 – Air Filtration Unit Specifications

2.3 EXPERIMENTAL SET UP

The OPC was set up in a dental surgery (see Figure 2) in Tonbridge, Kent from Monday 6th July to Thursday 16th July 2020. A continuous video (no audio) was set up to record the activities in the surgery. The size of the room was nominally 3.33 m x 4.54 m with a height of approximately 2.4 m giving a total volume of about 36 m^3. A window was open for all examinations and procedures, and high-volume suction through wide bore aspiration tips was applied during examinations. The OPC recorded data averages every 2 minutes and required manual data transfer every 24 hours. There are some gaps in the data due to data handling issues. The inlet of the equipment was placed approximately 1.5 m away from the dental chair. At times during the monitoring the dentist was positioned between the patient and the monitor, which is likely to have screened some generated aerosol from the monitor. An air filtration unit was used on its automatic setting from 14:00 on the 13th July and was positioned near the door of the surgery.

Figure 2 – Experimental setup in the surgery

3 RESULTS

3.1 OPC DATA

Figure 3 shows the long-term data of the OPC particle concentrations within the surgery. It can be clearly seen that there are many peaks above the background concentration, which is attributed to ambient (outdoor) sources and other slowly changing contributions. It should be noted that there were large variations in the OPC background, in the range of nominally 5 – 75 cm^{-3} (particles per cubic centimetre of air).

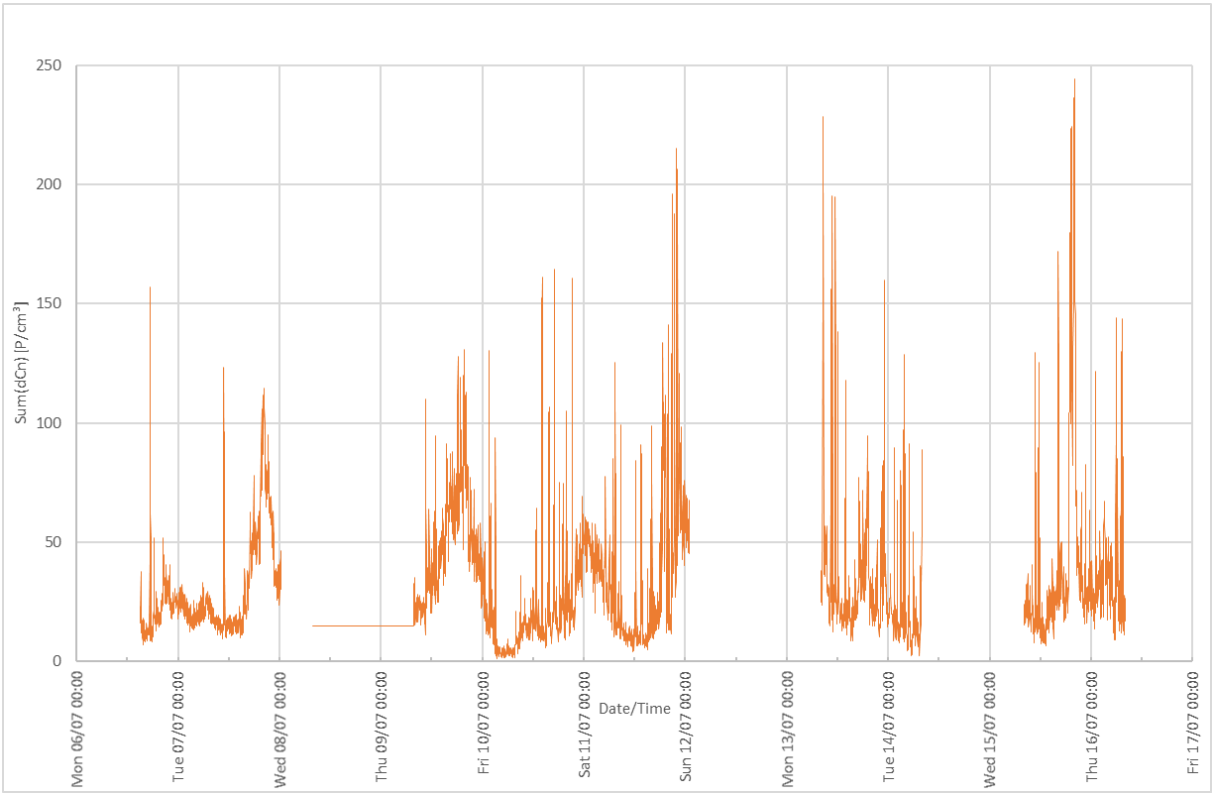

Figure 3 – Long-term OPC data over the measurement period

Peaks were identified by examining the peak height relative to its surrounding points, as well as the gradient of increase and decrease to and from the maxima. The width of the peak and therefore the duration of the particle event was determined and recorded. Figures 4a – 4f show this peak width determination for the measurement period.

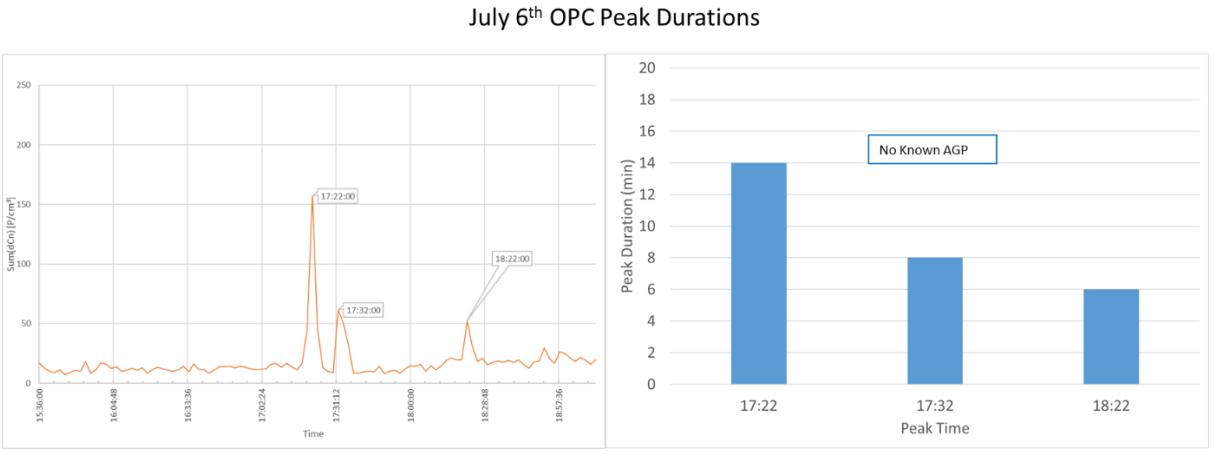

Figure 4a – OPC peak duration on 6th July

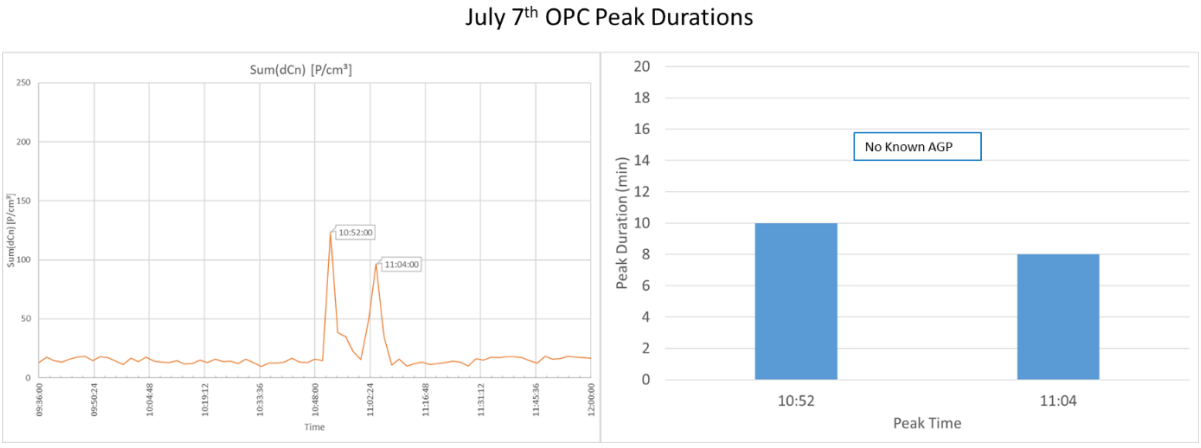

Figure 4b – OPC peak duration on 7th July

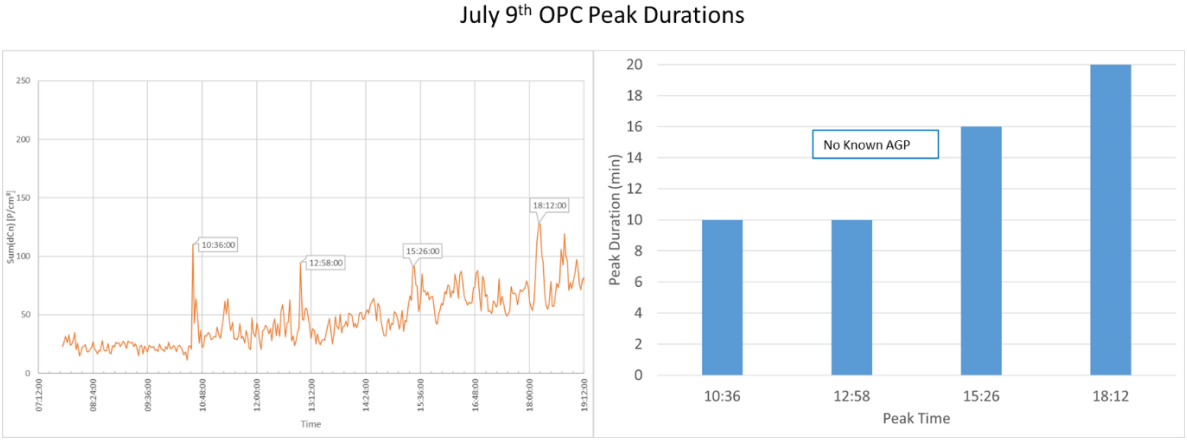

Figure 4c – OPC peak duration on 9th July

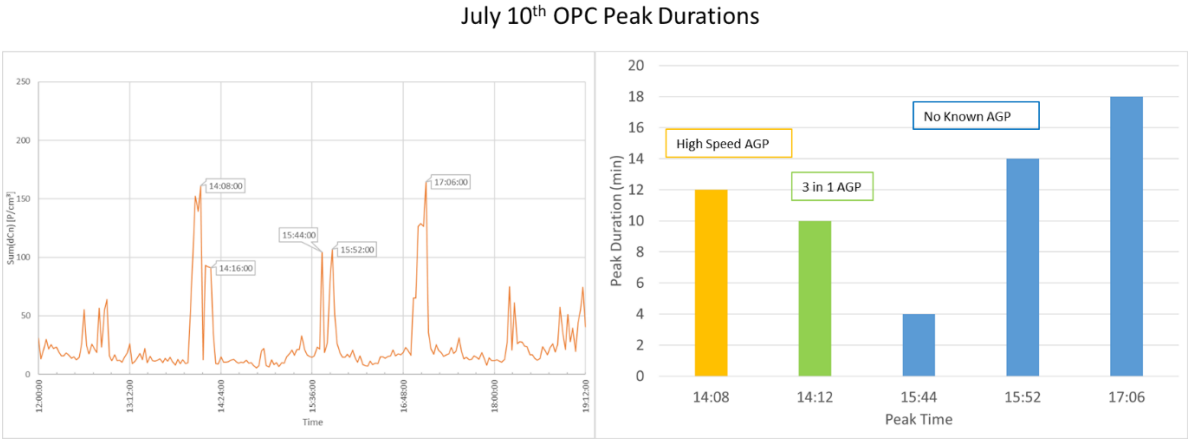

Figure 4d – OPC peak duration on 10th July

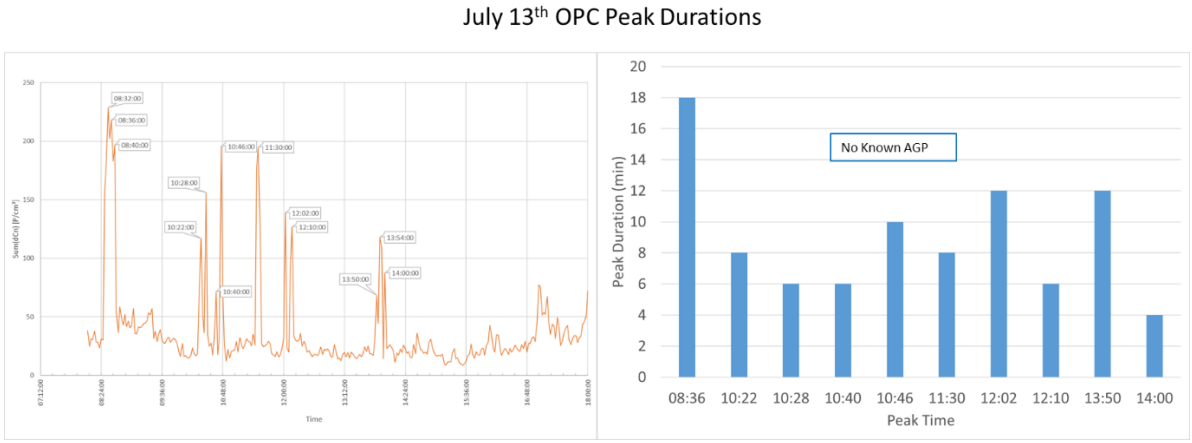

Figure 4e – OPC peak duration on 13th July

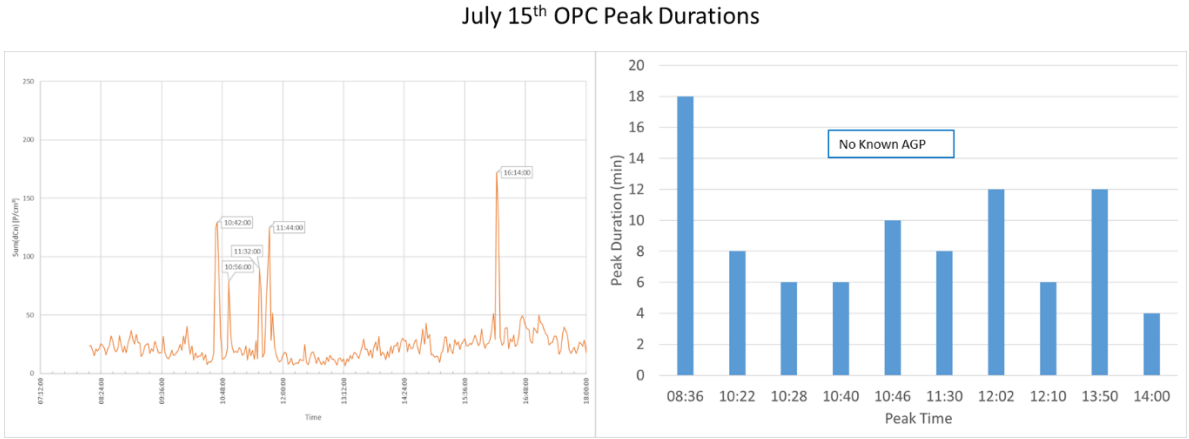

Figure 4f – OPC peak duration on 15th July

It is clear from Figures 4a-4f that there is no clear relationship between most prominent peaks within the day and the recorded AGP activities. However, whether or not a correlation was observed, the duration of the concentration spike above background was 20 minutes or less as shown in Figure 5. The average of the duration of the significant OPC peaks during the measurement period was 10 minutes.

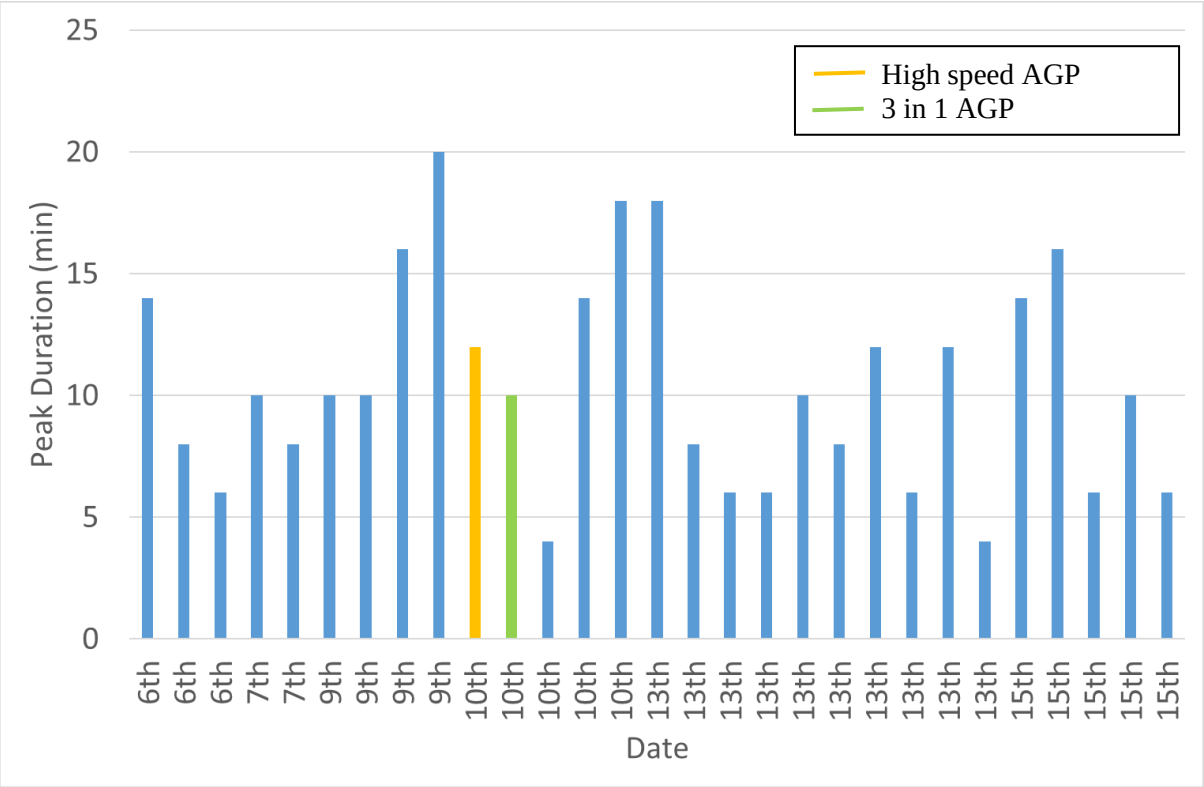

Figure 5 – Peak duration throughout the measurement period in July 2020

A total of 41 AGP events were monitored throughout the measurement period but all but 2 of them occurred away from the large OPC peaks. The use of the air filtration unit did not appear to significantly affect the duration of these OPC peaks as no clear reduction in peak duration was observed during the period that the air filtration unit was operating at an automatic setting, although there is only limited data for this period.

As is demonstrated in Figure 6, the AGP events for July 9th occurred away from the significant peaks of the day. Although fine structure can be seen in the background at the AGP times, it is very difficult to distinguish this from the background variations throughout the day. Therefore, although some peak correlation with AGPs may have been possible, it was decided that this should not be attempted as the risk of a false positive was too great, and the exercise would be of limited value.

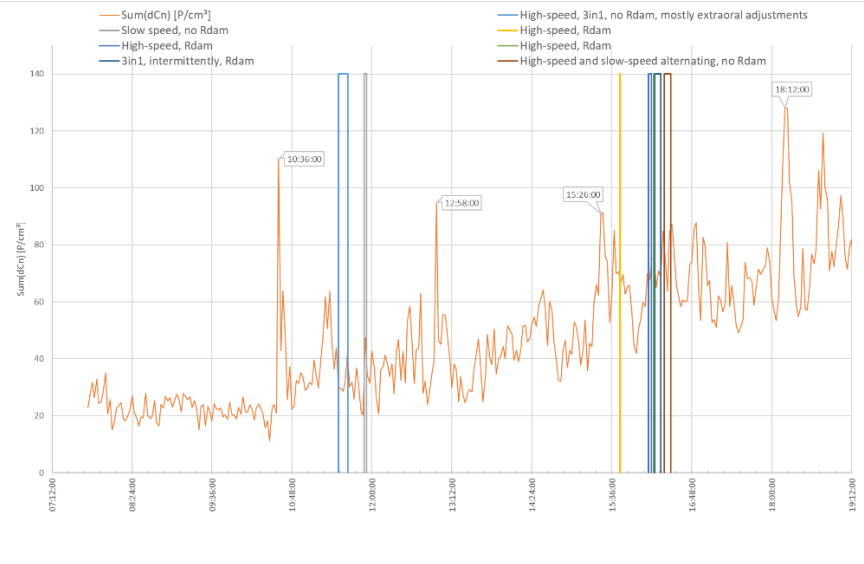

Figure 6 – AGP events overlaid on the OPC readings for 9th July

4 FINDINGS

- This study has suggested that even in a small surgery the impact of a variety of 41 AGPs, when used with mitigation procedures, on room aerosol concentrations was limited, at least at the location where sampling took place. Although peaks in airborne particle concentrations were seen during working hours at the surgery, they could not generally be attributed to any reported AGP procedures.

- Findings suggest that airborne particle concentrations (in the measured size range of 0.2 - 10 µm) were largely driven by ambient background levels and non-AGP events. Apparent correlations of increased concentrations with AGPs must be examined very carefully, as false source apportionment is a significant risk.

- The enhanced mitigation procedures in place for the AGPs during this study could have prevented peaks being observed during the majority of AGPs. The switching on of an air filtration unit at the automatic filtration setting (not the high flow setting) did not appear to significantly affect the OPC peak duration, although only limited data was available for this period.

- One clear point based on this single feasibility study (using one sampling location) is that, regardless of the source of the peaks in the OPC data, the duration of these events did not exceed 20 minutes. The mean event duration time was approximately 10 minutes.

- The results of this study can be used to inform the planning of a more detailed study with more sampling points, instruments and targeted sampling of AGPs.

5 CONCLUSIONS AND RECOMMENDATIONS

Whilst any correlation between the AGPs and particle detection was inconclusive, due to presence of background and non-AGP particles, these early results suggest a possible maximum measured duration of any event. It is recommended that an in-depth follow-on study is conducted to explore these early observations. This could include multiple OPC instruments from across the sensitivity and cost spectrum, with carefully positioned inlets to better capture the emissions from AGP procedures.

Although not included in this report, a Condensation Particle Counter (TSI 3775 CPC) and two AQMESH OPC instruments were also measuring particle concentrations during the test period. Whilst the CPC data may prove useful in the future, it has not been included here because the particle sizes that the CPC is sensitive to (down to 4 nm) mean that the concentrations are dominated by sub-micron particles, which are less likely to be produced by AGPs than by other sources. It is therefore even more difficult to separate out background readings for these than for the OPC.

The two AQMESH OPC instruments recorded particle concentration averages at an interval of 15 minutes. Although some of the long-term background trends in the PALAS OPC were followed, the lack of fine detail limited the usefulness of these measurements. In future studies a 1-minute resolution will be used.

It is therefore recommended:

i. That these findings be shared, in the first instance with members of the Scottish Dental Clinical Effectiveness Programme (SD CEP), and the Office of the Chief Dental Officer for England.

ii. That an application for a short term (20 day) M4R grant be made in order to undertake some small-scale testing in other clinical settings and to allow for further analysis and reporting of data taken from the Condensation Particle Counter (CPC) also used during the feasibility study.

iii. That an in-depth larger scale follow-on study is conducted to build on these findings to include the testing and validation of multiple OPC instruments from across the sensitivity and cost spectrum to better capture the concentrations of airborne particles in surgeries during AGP procedures.