Investigating steam penetration into dental handpieces

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Industrial scholarship in partnership with W&H
The role of the handpiece

Handpiece types:

Dental turbine:
  e.g. used to drill tooth

Dental slow speed motor:
  e.g. used to polish teeth

Straight handpiece:
  e.g. used for oral surgery
Background I

- Handpieces weak link in the dental infection prevention chain
- Handpiece cleaning and sterilization challenging = access to internal components and lumens e.g., stainless steel, D=0.9 mm & L=83 mm, in air driven turbines
- Weight: 42 – 100g
• Critical to remove air to achieve sterilization parameters (Perkins et al. 1956, Bowie et al. 1963)

• The risk of cross contamination has been raised – biofouling inside handpieces
Aims

- Investigate steam penetration into dental handpieces
- Investigate steam penetration into process challenge devices (PCD’s)
- Using N type and B type bench-top steam sterilization process.
Outline

• Thermometric study
  – Investigation steam penetration/air removal in dental handpieces by measuring temperature/time changes

• Chemical indicator study

• Biological indicator study
Thermometric Study

- **Method:**
  - Type N machines (N=1)
  - Handpiece types/makes:
    - Turbines (N=3)
    - Slow speed motors (N=2)
- **Loads**
  - Small
  - Full (as per sterilizer manufacturer’s instructions)
- **Orientation of handpieces:** horizontal in center of chamber
- **Control BDT**
Thermometric study

- Thermocouple investigations
  - Thermocouple = T type (2 mm x 1 mm, standard error less than 1°C)
    - Air channel d=2.3 mm, L=80 mm
  - Thermocouple = T type (D = 0.8 mm, standard error less than 1°C)
    - Spray channels d=0.9 mm, L=83 mm
Thermometric study

- **Data logger investigations**
  - Temperature sensors
    (Teflon, d=2 mm, approx. L=30 cm, accuracy ± 0.05°C)
  - Air channel d=2.3 mm, L=80 mm
  - Pressure sensors (accuracy 0.25%)
Calibration thermocouples:
Calibration equipment used
• Pressure calibrator (DRUCK)
• Hot block (AMETEK)
• Data logger (ANVILLE 825)

Calibration procedure:
• Thermocouples calibrated every 10 cycles

Calibration data loggers:
• Denmark
Thermometric Study

Typical type N profile

134°C

137°C

Pressure

Chamber

Holding time
Thermometric Study

Handpiece 1

Handpiece 2

Handpiece 3

Chamber

Pressure

134°C

137°C

A

B

C
Thermometric Study

Drive air channel
D=2.3 mm,
L=80 mm,
V=332 ml

Spray channel
D=0.9 mm,
L=83 mm,
V=0.045 ml

→ Thin thermocouples

→ Regular thermocouples

→ ellab data loggers
Thermometric study - Control

Type N BDT

Holding time

Chamber

Top BDT

Bottom BDT

Pressure

134°C

137°C
# Thermometric Study - Results

<table>
<thead>
<tr>
<th>N Type Manufacturer</th>
<th>Handpiece Manufacturer A (turbine)</th>
<th>Handpiece Manufacturer B (turbine)</th>
<th>Handpiece Manufacturer C (turbine)</th>
<th>Handpiece Manufacturer D (motor)</th>
<th>Handpiece Manufacturer A (motor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (holding time 6.5 min)</td>
<td>N = 192</td>
<td>N = 9</td>
<td>N = 9</td>
<td>N = 9</td>
<td>N = 9</td>
</tr>
<tr>
<td>Temperature lag of handpiece to chamber at 134°C</td>
<td>15 – 100 sec</td>
<td>23 – 80 sec</td>
<td>18 – 147 sec</td>
<td>13 – 38 sec</td>
<td>-1 – 8 sec</td>
</tr>
</tbody>
</table>
Thermometric Study - Results

N type Manufacturer A profile

[Graph showing temperature and pressure over time with annotations: Chamber and Pressure, and a highlighted area indicating 6.5 min.]
• Thermometric study

• Chemical indicator study
  investigate if chemical indicator strips (used in the Browne helix pcd, class 2) perform a pass at different locations inside the handpiece using a type N sterilization process

• Biological indicator study
  determining whether a non-vacuum sterilization process effectively inactivates spores of Geobacillus stearothermophilus
**CI and BI Study**

- **Method:**
  - Type N machines (N=4)
  - Type B machines (N=1)
  - Handpiece types/makes:
    - Turbines (N=1)
    - Slow speed motors (N=1)
    - Surgical handpiece (N=1)
  - Loads
    - Small
    - Full (as per sterilizer manufacturer’s instructions)
  - Orientation of handpieces: horizontal in center of chamber

- Control Browne’s helix pcd, BDT
• **Method:**

• ellab data loggers (teflon, D = 2 mm)

• Browne’s Helix chemical indicators (class 2)

• *Geobacillus stearothermophilus* spores on paper strips (Excelsior, population $2.5 \times 10^6$ spores per strip, $D_{121} = 2.3$ min)
CI and BI Study

• **Method:**

• **Chemical indicators:**
  – Visual assessment

• **Spore recovery method:**
  – TSB at 56°C
  – Checked for growth every 24 h over 8 days
  – Plated onto Tryptone Soy Agar → Gram Stain
CI and BI Study
Air turbine

Drive air channel
50 mm x 2 mm

Spray channel
50 mm x 0.8 mm

Turbine head
5 mm x 1.5 mm

- d=2.3 mm, l=80 mm, v=0.332 ml
- d=0.9 mm, l=85 mm, v=0.054 ml
Typical type N profile

Holding time

Chamber

Pressure

137°C
134°C
Typical type B profile

137°C
134°C

Chamber

Pressure

Holding time
Cl and BI Study - control

10 mm x 2 mm
### CI and BI Study - Results

1 + 1 (safety) min at 134°C (Perkins, 1956) → 2 + 1 (safety) min at 134°C (1st MRC report)

<table>
<thead>
<tr>
<th>3 sets of 3 different handpieces per cycle</th>
<th>Type N Manufacturer A</th>
<th>Type N Manufacturer B</th>
<th>Type N Manufacturer C</th>
<th>Type N Manufacturer D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holding time at 134°C</td>
<td>6 min 30 sec</td>
<td>6 min 30 sec</td>
<td>3 min 30 sec</td>
<td>4 min 10 sec</td>
</tr>
<tr>
<td>Temperature lag of handpiece to chamber at 134°C</td>
<td>15 – 100 sec</td>
<td>25 – 39 sec</td>
<td>25 – 40 sec</td>
<td>0 – 2 sec</td>
</tr>
<tr>
<td>BI fail</td>
<td>0/108</td>
<td>1/108</td>
<td>5/126*</td>
<td>0/108</td>
</tr>
<tr>
<td>CI fail</td>
<td>0/108</td>
<td>0/108</td>
<td>6/126*</td>
<td>0/32</td>
</tr>
</tbody>
</table>

* straight surgical handpiece back
Conclusions

• Steam penetration into dental handpiece lumens is impaired using type N process.

• More difficult to ensure sterility in surgical handpieces.

• It can not be assumed that all type N machines and all handpiece types are compatible.
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