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RESPONSE OF PULP AND SUPPORTING TISSUES TO THERMAL CHANGES

Dentistry

Dr. Rajendra P. Bharatiya PHD Scholar, Gujarat Univercity

Dr. Girish J. Parmar PHD Guide, Gujarat Univercity

ABSTRACT

Dental procedures often induce temperature increases on tooth surfaces, raising concerns about pulp and tissue damage. This research addresses safe temperature ranges and temperature increases during dental procedures.Studies show conflicting findings on safe temperature ranges, with increases ranging from 0.8 to 40.4˚C. Factors like handpiece type and curing unit influence variations. In vivo research suggests lower increases due to thermal dissipation. Thermal irritation during clinical procedures:1. Tooth Preparation: Electric micromotors may lead to lower temperature increases compared to air turbines. The impact of torque and air pressure remains inconclusive. 2. Light Curing of Composite Resin: Higher light intensity raises intrapulpal temperature, with variations between light-curing units and materials. 3. Ultrasonics in Root Canal Therapy: Ultrasonic devices generate heat but remain below dangerous thresholds with water spray. 4. Thermo-Plasticized Root Canal Obturation: Periodontal blood flow ensures temperatures remain below critical thresholds. 5. Post Space Preparation: Factors like drill type and diameter affect temperature rise, emphasizing caution. **Conclusion:** Dental procedures risk pulp damage and tooth loss due to heat generation. Future research should replicate intraoral conditions accurately to monitor temperature changes effectively.

KEYWORDS

Thermal Irritation, Dental Procedures, Pulp Damage, Temperature Rises

INTRODUCTION

Various dental procedures, such as tooth preparation, composite resin restoration, and root canal treatment, are known to cause temperature rises on tooth surfaces. This issue raises two main questions: (a) what temperature range is safe to avoid thermal damage to the pulp and tissues, and (b) how much does temperature increase during dental procedures?

Previous studies have shown conflicting results regarding the safe temperature range. For example, zach and cohen's study on monkeys found that a 5.5˚C increase in intra-pulpal temperature led to pulpitis or necrosis in 15% of teeth [1]. Another study by eriksson and albrektson noted that a 10˚C rise in outer root surface temperature caused bone resorption and tooth ankylosis [2].

Tooth preparation resulted in surface or pulp temperature rises ranging from 0.8 to 3.0˚C [3] Composite resin photopolymerization raised intra-pulpal temperature by up to 7.8˚C, while fabricating provisional crowns with acrylic resins raised it from 3.4 to 12.3˚C [4]. Root surface temperature during thermo-plasticized canal obturation, increased by 6.5 to 22.1˚C, and using ultrasonic devices raise root surface temperature by up to 40.4˚C [5].

These temperature variations are influenced by factors like measuring methods, remaining dentin thickness, handpiece type, curing unit, ultrasonic device used and presence of a water spray. [6].

This research aims to investigate temperature increases during dental procedures and provide clinical guidelines to mitigate thermal damage.

Thermal irritation during various clinical procedures:

1. Tooth preparation with high- and low-torque handpieces

There are two main types of high-speed dental handpieces (hsdhs): electric micromotors and air turbines. Electric micromotor-driven handpieces offer greater cutting efficiency and torque stability compared to air turbine handpieces [7]. While air turbines reach higher speeds, they lack torque stability, which can result in decreased cutting efficiency under high loads.

One study suggests that electric handpieces may lead to a greater decrease in intra-pulpal temperature compared to air turbine handpieces due to improved cutting efficiency and friction production [8]. However, this finding lacks validation from other studies.

The speed and power of hsdhs are directly related to generated energy and can result in increased intra-pulpal temperature. However, electric hsdhs generate more heat within the handpiece body, potentially leading to soft tissue injuries without effective cooling mechanisms [9].

2. Light curing of composite resin:

Higher intensity led lights raised intrapulpal temperature more than lower intensity halogen lights, emphasizing light intensity over light source type. While previous studies highlighted factors like the type of light-curing unit (lcu) and materials, other studies results contradicted some, showing greater temperature rises with halogen lights for darker shades but lower with leds [10].

In vitro investigations of thermal changes during light-activated polymerization of resin-based composites (rbcs) often lack standardized methods. Zach and Cohen (1965) suggest heat adversely affects pulpal health, but recent research challenges this, focusing on inflammatory responses to heat as a noxious stimulus [11].

Clinical relevance was emphasized by bonding rbc restorations, as their polymerization generates significant heat. Infrared camera studies indicate considerable variability in intrapulpal temperature change during rbc polymerization, influenced by factors like curing tip placement and restoration size, which are difficult to standardize in vivo [12].

3. Use of ultrasonics in root canal therapy:

Ultrasonic devices in dentistry operate at frequencies of around 20-50 khz, generating synergistic effects through vibration energy from the cavitron generator [13]. These devices are used for various endodontic treatments such as canal irrigation, post removal, and retro-preparation during surgery. While they offer advantages like improved irrigation efficacy and reduced postoperative discomfort, heat generated from friction during use poses risks to tooth-supporting tissues. Studies have compared intrapulpal temperature rises during tooth preparation with ultrasonic devices to those with high-speed handpieces and lasers, indicating higher temperatures with ultrasonics but still below dangerous thresholds, especially when water spray is sufficient [14].

Research shows substantial temperature increases during post removal, with ceramic and metal posts both exhibiting significant rises. Factors like ultrasonic power setting, tip type, and water-cooling quantity significantly affect temperature rise during post or file removal. Insufficient cooling and high-power settings can lead to thermal damage, emphasizing the importance of adhering to clinical guidelines to minimize such risks [15].

4. Thermo-plasticized root canal obturation:

Both continuous-wave and vertical compaction techniques for gutta-percha (gp) obturation, are commonly used in clinical practice. Previous reports suggested that these heated obturation methods would not raise the periodontal ligament (pdl) temperature above critical threshold for bone injury (10°c above body temperature) [16]

However, most studies were conducted on extracted teeth in controlled environments, which may have underestimated temperature increases due to heat loss to the surrounding environment.

Thermocouples only measure temperatures on outer root surface, ignoring heat dissipation by blood circulation in the pdl, which significantly influences heat dissipation during obturation [17].

Various studies, showed that a pdl layer reduces temperature rise, further reduced with blood circulation, regardless of the obturation technique or canal type. The cooling effect of pdl blood flow was evident, ensuring temperatures remained below the critical threshold for bone injury [18].

Monitoring temperature fluctuations during procedure revealed that tissue damage is unlikely if duration of maximum temperatures remains under 5 seconds, highlighting the importance of further research on duration of temperature rise above critical threshold with different obturation techniques.

5. Post space preparation:

Gates glidden drills, peeso reamers, ultrasonic and specific drills are recommended for post space preparation. The length and diameter of post are crucial for retention and resistance to fracture, with a minimum 6 mm apical seal recommended. Using engine-driven drills for post space preparation may generate temperature rises that could damage periradicular tissue [19].

Our study found temperature increases ranging from 4.5°c to 9.1°c during root post space preparation, indicating safe speeds below 10°c. Another study using higher speeds showed temperature increases ranging from 0.66°c to 4.81°c, with no significant difference in temperature between speeds over 8000 rpm. Saunders et al. Recorded temperature rises of up to 31°c during gutta-percha removal combined with post channel preparation [20].

Studies comparing techniques for removing obturating material during post space preparation showed significant temperature increases, with beefill pack system causing a temperature rise of up to 11.3°c. Higher overheating values were reported when smaller reamers were used [21].

Various factors can affect temperature rise during post canal preparation, including operator force, drill type and diameter, root canal anatomy, friction between dentin and drill, use of water coolant, and drill condition. Results may vary depending on the device used for temperature measurement, the number of thermocouple tips, and the teeth used [22].

CONCLUSIONS

Dental procedures can generate harmful heat, risking pulp damage and tooth loss. Despite its importance, research on influencing factors and related procedures is limited.

Residual dentin thickness is crucial for managing temperature during procedures, acting as a protective barrier. Caution is necessary when thickness is less than 1 mm to avoid pulp or tissue damage.

Clinicians should be vigilant about potential thermal hazards during routine procedures, following guidelines such as using water cooling during tooth preparation and employing cooling techniques for root canal obturation

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