

FLIR Technical Series

Application Note for Research & Science

The evaluation of increase and distribution of temperature during the dental drilling using a thermal imaging camera

Joanna Lubieniecka, M. Sc. Eng.
Air Force Institute of Technology, Poland

Jerzy Lukasiewicz, M. Sc. Eng.
Air Force Institute of Technology, Poland

Joanna Bozyk, MDS
Medical University of Lublin

Janusz Kleinrok, DMD
Perfect-Dent Lublin

Abstract

Currently, the most popular restorations in reconstructive dentistry are fixed dentures such as inlays, onlays, dowel cores (posts), crowns and bridges, veneers, and implants. Making a dowel core (post) by preserving an endodontically-treated tooth with an extensively damaged crown is advantageous to the patient for many reasons. The patient has mental comfort having their "own" tooth. Additionally, the remaining periodontal ligament around the tooth root left by this procedure allows effective chewing since pressure can still be felt. There is no bone structure loss which can occur after the complete removal of a tooth. Finally, the newest technologies in contemporary dentistry that employ glass fibers, composite resins, and porcelain allow the dentist to achieve highly pleasing cosmetic results.

Preparation for a post procedure requires using a drill or specific reamer on dental drill. However, rotary speeds may cause a dangerously high rise in temperature. It is generally agreed that temperatures above 56 to 60°C are deleterious to bone tissue as they give rise to denaturation of hard tissue proteins. It is also known that a temperature of 47°C or above on the surface of the dental root -10°C higher than regular body temperature - may cause thermal damage to surrounding tissues: cementum, periodontium, and alveolar bone.

This study presents measurements of temperature of teeth taken with a high-speed camera, a FLIR SC6000 with an InSb detector, during the dental drilling.

Introduction

This paper discusses the use of infrared technology to study the optimal method for post space preparation of teeth including how long to drill, the type and size of dental drill used, and the type of cooling used.

Space preparation of a tooth for a dental crown requires loss of hard tooth tissues in order to meet the dual requirements of necessary resistance and esthetics. At the moment, the most aesthetically pleasing restorations of teeth are restorations based on the zirconium oxide or alumina with no metal substructure. They need preparation of tooth tissues to about 2 mm. Since drilling may generate high temperatures and cause dental pulp

Informational Disclaimer:

FLIR's R&D/Science cameras are intended for use as a tool for product development and research exclusively. The following information is in relation to product development applications and not directly for patient care or diagnosis.



damage, especially in teeth with large fillings, many authors recommend endodontic treatment and a dowel core as the first stage of the reconstructive treatment. [2,6,13].

Other indicators that a dowel core is a necessity in preparing one or more tooth walls include:

- Equalization of the occlusal plane
- Improvement of esthetics (correction of extensively protruding and/or misaligned teeth)
- When a dental bridge is necessary on teeth that have migrated to a void. Endodontically-treated teeth with dowel cores provide sufficient retention for fixed prosthetic restoration. [5,6,7,9,12].

Measurement

For these tests, sixty one-root premolars were used. The one-root teeth are regarded in the literature as teeth with the least variability of dimension and shape among all human permanent teeth. Sex, age, and the reason for extraction were unknown. Directly after the extraction, they were stored for seven days in 5% solution of sodium hypochlorite. Before testing, the samples were mechanically cleaned and put in saliva solution for 24 hours. Then, the access to the chamber of the tooth was gained with the turbine drill with water-air cooling and the access was extended with further drilling. Teeth were endodontically-treated with Densply-Maillefer hand and rotary instruments, profiles 0.2", according to the crown-down technique. Root canals were widened to size 35 (green) with the distance of approximately 1 mm from the apical foramen, left. During the procedure, the canals were rinsed with 2.5% solution of chlorhexidine. After the mechanical preparation, the canals were rinsed out with distilled water, then drained with paper points. The canals prepared in this way were filled with gutta-percha with a sealer using the lateral condensation method.

Samples were put in a special holder expected to meet specific requirements:

- Material in a direct contact with the tooth should have low thermal permeability and not collect heat from the sample.
- The testing set should provide the infrared camera access to the dental root along the entire length, without covering any of its parts.
- It should not disrupt measurements with the infrared camera.
- It should hold samples stable,.
- It should not exert any crushing force which could cause fractures on the surface of the sample.

As a part of temperature measurements during the post space preparation, water-cooling conditions were considered. The root part of the tooth was isolated in such a way that it had no contact with the cooling factor, and the cooling affected only the place of preparation. It was intended to represent clinical conditions, in which water-cooling takes place exclusively from the coronal side of the tooth. The root part was isolated from the coronal part with elastic foil closely adhering to the anatomical neck of the tooth.

The thermal measuring system included:

- A FLIR SC6000 HSDR thermal camera
- 13 mm lens with close-up attachment
- FLIR RTools software

The measuring conditions were:

- Frame rate of sequence: 85 f/s
- Resolution of the thermal image: 640 x512 pixels
- Emissivity: $\epsilon=0.94$
- Distance between the object and the camera: 11 cm

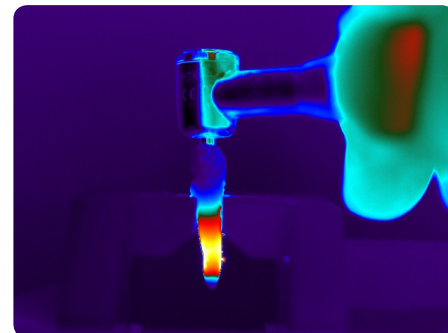


Figure 1. The thermal image of a tooth during drilling at the testing stand.

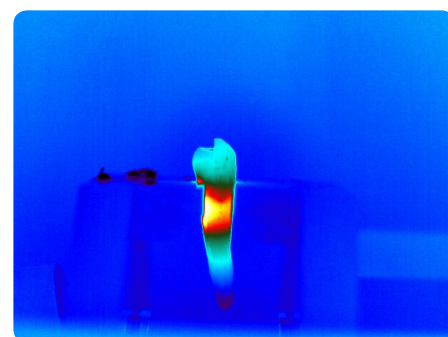


Figure 2. The thermal image of a tooth after drilling.

In the testing work, a micro-engine was used, with the capability of speed control in the range 1,000 to 20,000 rpm. The following rotational speeds were used in the testing work: 1,000, 2,000, and 5,000 rpm. The NSK handpiece was used. Because the available micro-engine didn't have its own water-cooling system, water was applied from a syringe with a needle. Room temperature was the initial temperature.

Three types of drills were used corresponding to 3 systems of prefabricated dowel-cores:

- RadixAnker System – a cylinder-shaped drill bit
- Oident System – a conical-shaped drill bit
- OptiPost System – a stepwise-shaped drill bit

Preparations were conducted in conditions similar to clinical ones, according to manufacturer's recommendations, that is, sequentially: the piloting drill, the widening drill, and the final shape drill.

Results

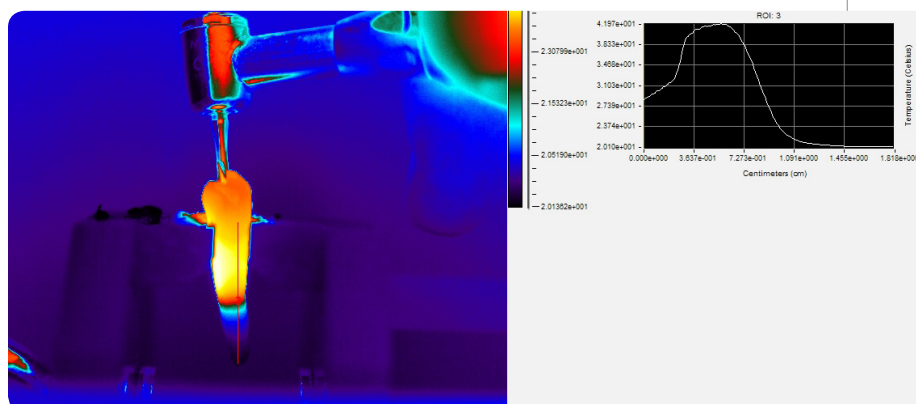


Figure 3. Left: The thermal image of a tooth during drilling without cooling. Right: Temperature diagram.

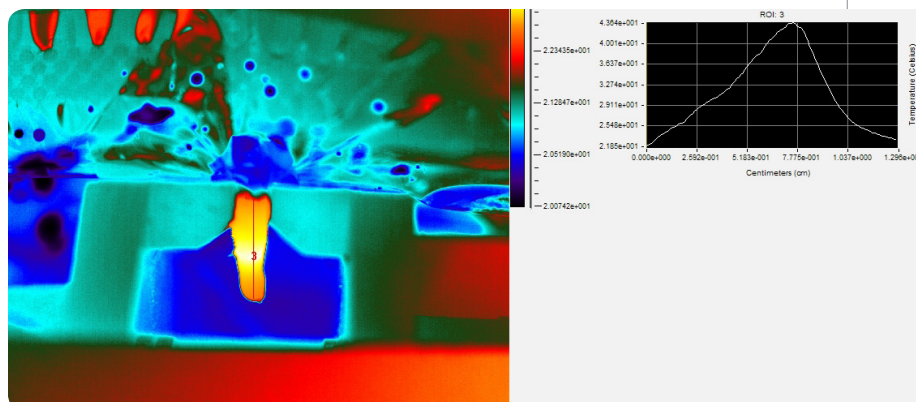


Figure 4. Left: The thermal image of a tooth during drilling with water cooling. Right: Temperature diagram.

The following graphs show the distribution of temperature along the tooth root from the apex to the line of the neck. The water-cooling effect was most pronounced in regions of the tooth neck. In this area, the temperature was very close to initial temperature reading. The highest temperature on the surface of the root corresponded to the largest depth that the drill reached in the tooth canal. The root apex surroundings tissue experienced very little to no temperature increase.

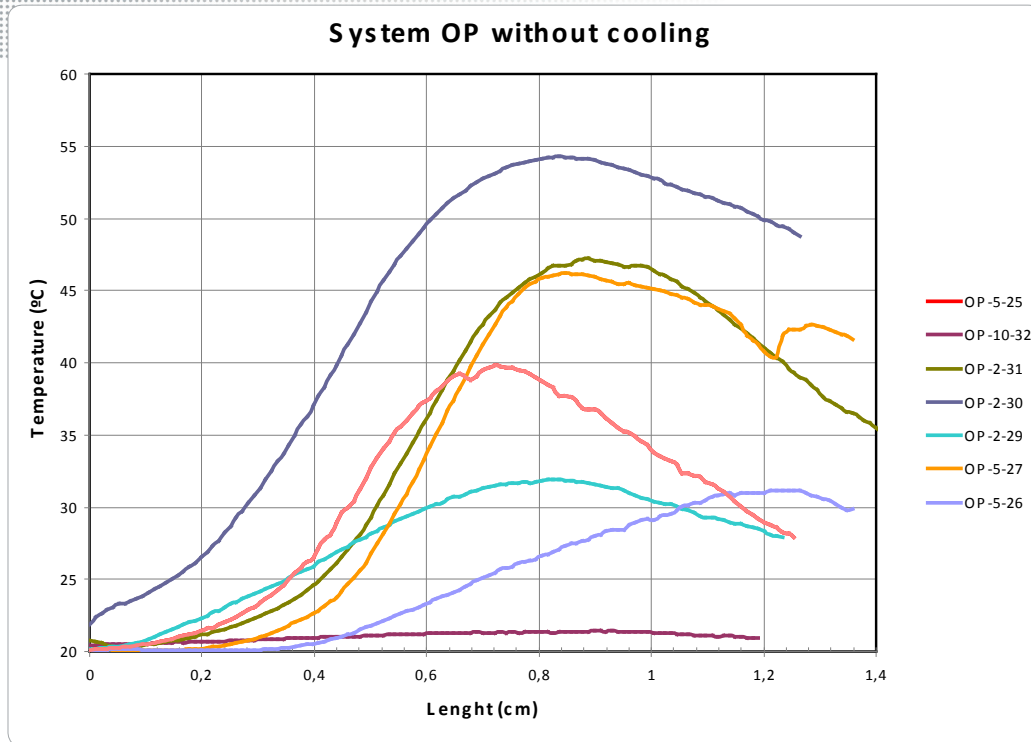


Figure. 5. The temperature distribution along the tooth root – the OptiPost system without cooling.

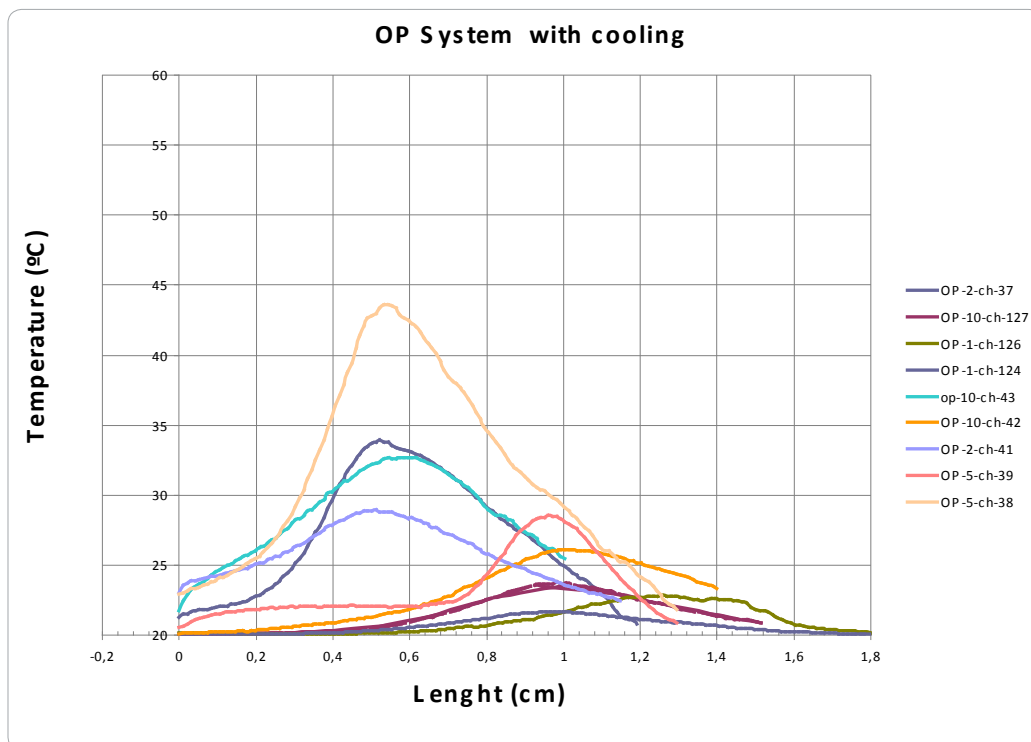


Figure. 6. The temperature distribution along the tooth root – the OptiPost system with cooling.

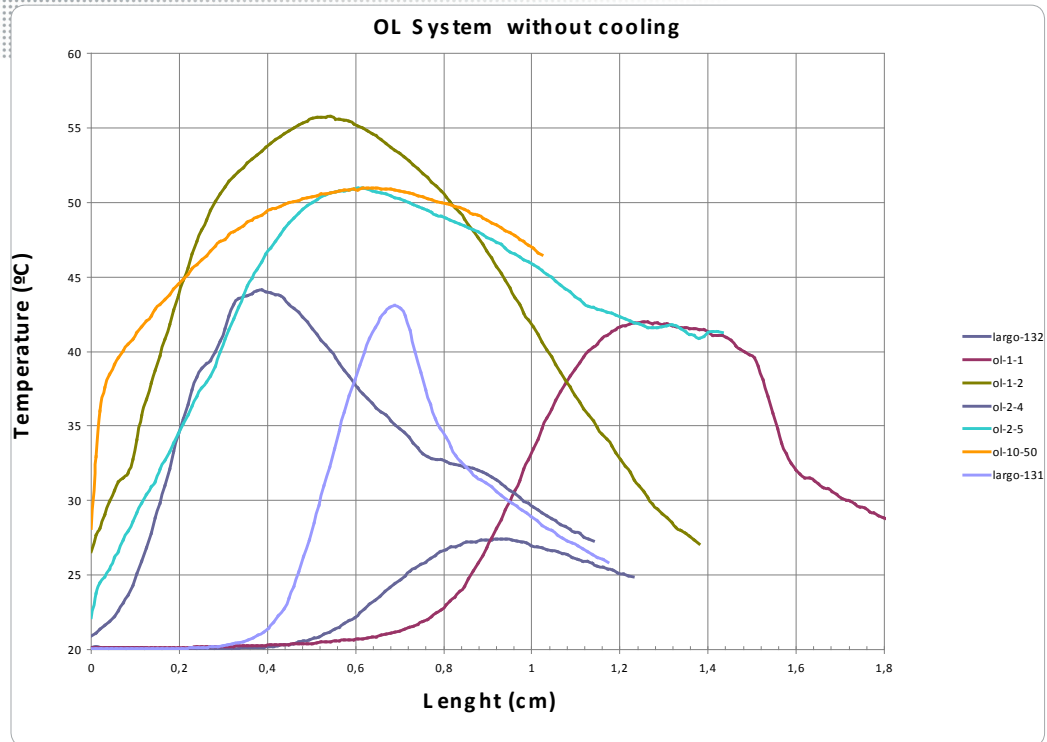


Figure. 7. The temperature distribution along the tooth root – the Olident system without cooling.

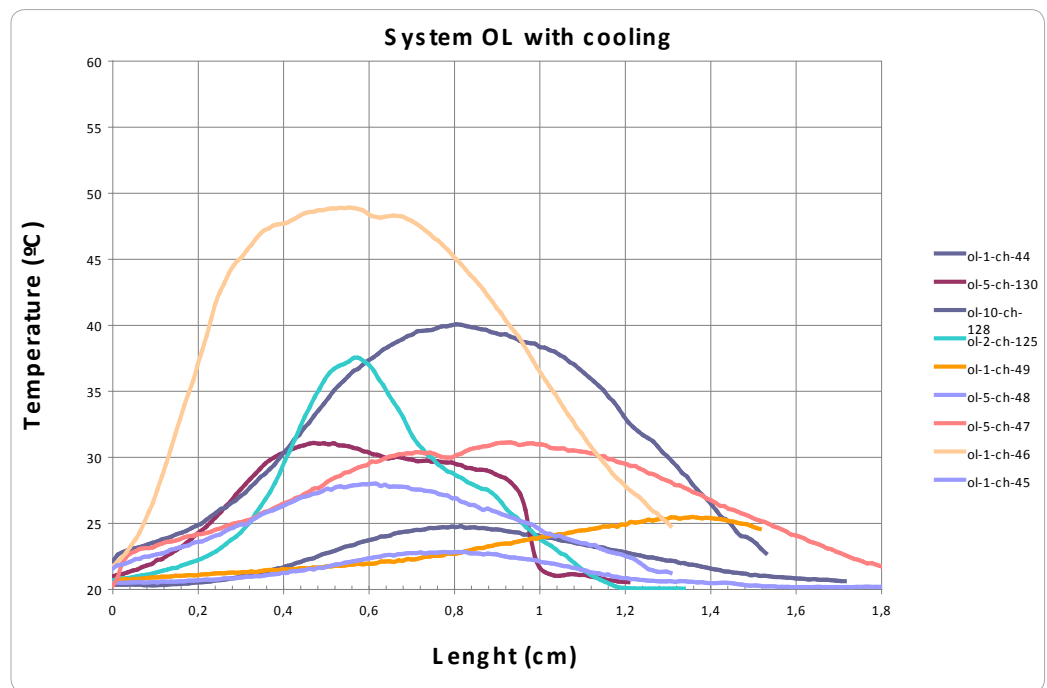


Figure. 8. The temperature distribution along the tooth root – the Olident system with cooling.

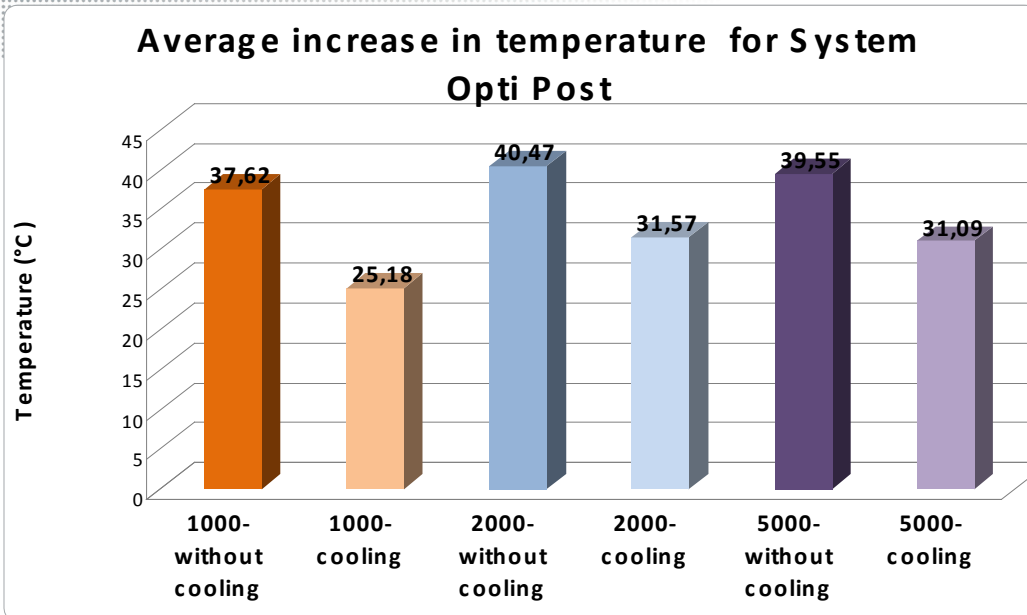


Figure. 9. Average increase in temperature for drilling without and with cooling for 1000, 2000, 5000 rev/min.

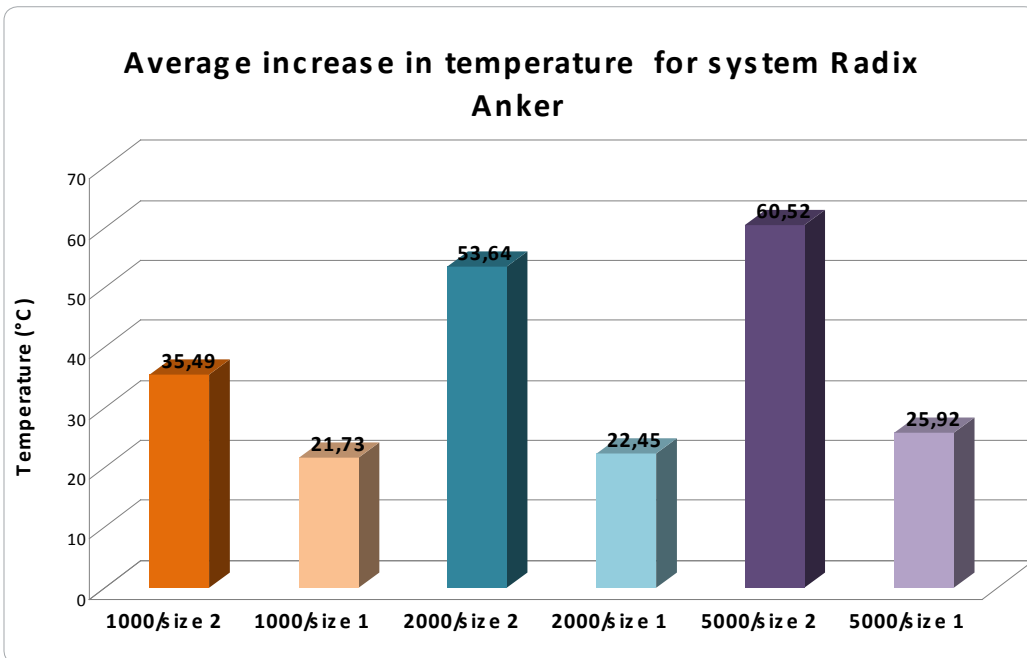


Figure. 10. Average increase in temperature for drilling with 1000, 2000, 5000 rev/min speeds and two sizes of drill.

Summary

Determining the optimal conditions for post space preparation is crucial in making long-lasting fillings possible. Using the high-resolution and high-speed thermal imaging system provided by the FLIR SC 6000 HS allowed evaluation of the increase and distribution of temperature dependent on the rotational speed of a dental borer, the type of a dental borer, and the type of cooling.

References

1. Atrizadeh F., Kennedy J., Zander H.: Ankylosis of teeth following thermal injury. J. Periodont. Res. 6, 1971, 159-167
2. Baum L., Philips R.W., Lund M.R.: Textbook of Operative Dentistry W. B. Saunders Comp., Philadelphia, 1985
3. Eriksson A., Albrektson T., Grane B., McQueen D.: Thermal injury to the bone. A vital-microscopic description of heat effects. Int. J. Oral Surg. 11, 1982, 115-121
4. Fors U., Jonasson E., Bergquist A., Berg J.O.: Measurements of the root canal surface temperature during thermo-mechanical root canal filling in vitro. "Int. End. J. 18, 1985, 199-202.
5. Goerig AC, Mueninghoff LA, Management of the endodontically treated tooth. Part I. Concept for restorative designs. J Prosthet Dent 1983; 49: 340-345.
6. Ingle J.I., Bakland L.K.: Endodontics BC Decker Inc Hamilton. Londyn 2002
7. Kryszynski Z. Protetyczna przydatność zębów leczonych endodontycznie. Czas. Stom. 1997
8. Lipski M., Wozniak K.: In Vitro Infrared Thermographic Assessment of Root Surface Temperature Rises During Thermafill Retreatment Using System B. J. Endod. 29, 6, 2003, 413-415
9. Limanowska-Shaw H.: Endodoncja w aspekcie leczenia protetycznego. Prot. Stom. 5, 2004, 301-306
10. Lee F.S., Van Cura J.E., BeGole F.: A comparison of root surface temperatures using different obturation heat sources. J. Endod. 24, 9, 1998, 617-620.
11. Majewski S.W.: Podstawy protetyki w praktyce lekarskiej i technice dentystycznej Wyd. Stomatologiczne SZS-W Kraków, 2000.
12. Majewski S.W. Rekonstrukcja zębów uzupełnieniami stałymi. Wyd II, Wydawnictwo Fundacji Rozwoju Protetyki, Kraków, 2005.
13. Pitt Ford T. R.: The Restoration of Teeth. Blackwell Scientific Publication. Oxford, 1992.

About the Author

Joanna Lubieniecka is a Level I thermographer and has been using the technology for 15 years.

BOSTON

FLIR Systems, Inc.
25 Esquire Road
North Billerica, MA 01862
USA
PH: +1 866.477.3687
PH: +1 978.901.8000

PORTLAND

Corporate Headquarters
FLIR Systems, Inc.
27700 SW Parkway Ave.
Wilsonville, OR 97070
USA
PH: +1 866.477.3687

CANADA

FLIR Systems, Ltd.
920 Sheldon Ct.
Burlington, ON L7L 5L6
Canada
PH: +1 800.613.0507

MEXICO/LATIN AMERICA

FLIR Systems Brasil
Av. Antonio Bardella
320 - B. Boa Vista- Cep:
18085-852 - Sorocaba - SP - Brazil
PH: +55 15 3238 8070