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ORIGINAL ARTICLE

A survey on root canal obturation trends: warm versus cold obturation technique

ABSTRACT

Aim: *The purpose of this study was to obtain information about the current trends on obturation between members of endodontic societies, affiliated with the European Society of Endodontology, specifically the trends of using calcium silicate-based sealers and the preferred use of the warm versus cold obturation technique related to years of practice, additional training in endodontics and working situation.*

Methodology: *A questionnaire was distributed, and data from Portugal, Italy and Turkey societies was collected for demographic and professional information, and also about material and techniques commonly used in endodontic obturation. Statistical analysis comprised descriptive statistics, presented as frequencies (n) and percentage (%). A chi-square test of homogeneity and a Z Test were conducted between obturation technique (warm versus cold) and years of practice, additional training in endodontics and working situation. A significance level of 0.05 was considered.*

Results: *The proportion of users of warm obturation technique was 58.7% and of cold obturation technique was 41.3%. The most selected sealer was the epoxy resin-based sealer (52.3%). Within the calcium silicate-based sealers, BioRoot was the most selected (40.3%). When calcium silicate-based sealers were selected, the majority of participants answered not to use the bioceramic gutta-percha cones (65.4%). The years of practice, the additional training in endodontics and the working situation influenced the selection of warm or cold obturation technique (p<.001).*

Conclusions: *The choice of warm or cold obturation technique showed association with the years of practice, the additional training in endodontics and the working situation.*

Isabel Vasconcelos*

Cátia Manilha

António Ginjeira

[1]*Department of Endodontics, Faculty of Medicina Dentária, Lisbon University, Lisbon, Portugal*

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Corresponding Author
Isabel Vasconcelos | Department of Endodontics, Faculty of Medicina Dentária, Lisbon University, Rua Professora Teresa Ambrósio, Cidade Universitária, 1600-277, Lisbon | Portugal
Tel: +351 217922600; Fax: +351 217957905 | Email: isabelvascon@hotmail.com

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Introduction

A complete sealing of the root canal system after cleaning and shaping is critical to prevent oral pathogens from colonizing and re-infecting the root canal system and periapical tissues (1). The aim of root canal obturation is to prevent coronal leakage, prevent influx of periapical fluids and entomb remaining bacteria in the root canal (1). A root canal obturation with no voids, extending to 2 mm within the radiographic apex and a satisfactory coronal restoration were found to improve the outcome of primary root canal treatment (2).

Over the years, new materials are being developed and a variety of sealers have been employed in root canal obturation. The requirements for materials to fill the root canal system are: biocompatibility, dimensional stability, ability to seal, insolubility, non supportive of bacterial growth and radiopacity (3). Various kinds of endodontic sealers are available, including sealers based on glass ionomer, zinc oxide-eugenol, resin, calcium hydroxide, silicone, and recently calcium silicate-based sealers, which has been associated to a reconsidered single cone technique, as an easier and faster obturation technique. When introduced into the market, calcium silicate-based sealers were claimed as an advantage for use in a cold obturation technique.

The lateral compaction is also a cold obturation technique, which is taught and practiced worldwide, serving as the gold standard against which new techniques must be compared (4). But the well-known shortcomings of the lateral compaction technique might decrease the effectiveness of root canal obturation, and several filling technique variations have been developed to incorporate the use of thermal or frictional heat, with the aim of thermoplasticizing the gutta-percha (5). The complex canal anatomy with accessory and lateral canals, isthmus and bifurcations, or with oval-shaped canals can make obturation a challenge. In the 1960's, the warm obturation technique was introduced in endodontics with the objective of thermoplasticizing the gutta-percha in order to adapt it to the irregularities of the root canal system. The idea of three-dimensional root canal obturation gained popularity among the specialists in endodontics with warm vertical compaction (6). Modifications to the technique have been applied. The System B endodontic heat source unit (EIE/Analytic, Redmond, WA, USA) was designed to thermoplasticize the apical gutta-percha with a single continuous wave (7). However, the root canal complex areas may be unfilled, even when termoplasticized gutta-percha is applied (5).

Since there are multiple techniques and materials available, and as there are no reports only focused on the warm or cold obturation preferences, the aim of this study was to clarify the tendency of selection of these two techniques associated on years of practice, additional training in endodontics and working situation.

Materials and Methods

An invitation to participate in the study was sent by email to all the country representatives of all national endodontic societies of the European Society of Endodontology (ESE), requesting collaboration from their registered endodontic practitioners. The email was sent directly to the societies representatives, who then forwarded the invitation to their members, which included instructions and details regarding the study's purpose. Three contacts to the societies were made in order to obtain the maximum compliance. The first was in December 2018, then March 2019 and finally in May 2019.

The questionnaire comprised nine questions divided in two parts (figure 1). The first part included social and professional data with five questions: gender, years of experience as endodontic practitioner, country where the respondent works, type of additional training in endodontics, and working situation. The second part included four questions related to obturation (techniques and materials): obturation technique more often used by the respon-

Questionnaire

1. Gender

( ) Female ( ) Male

2. How many years have you been practicing as an endodontic practitioner?

( ) <5 years ( ) 5-10 years ( ) >10 years

3. In which country do you practice?

( ) Austria ( ) Belgium ( ) Denmark ( ) Estonia ( ) Finland ( ) France ( ) Germany ( ) Greece ( ) Israel ( ) Italy ( ) Latvia ( ) Lithuania ( ) Luxembourg ( ) Norway ( ) Portugal ( ) Republic of Ireland ( ) Spain ( ) Sweden ( ) Switzerland ( ) The Netherlands ( ) Turkey) United Kingdom ( ) Other_____

4. What type of additional training do you have?

( ) Full-time post-graduation ( ) Part-time post-graduation ( ) Non- Structured training ( ) None

5. Which of the following describes your working situation?

( ) Full-time private practice ( ) Part-time private-practice/Part-time academic ( ) Academic

( ) National Health Service

6. Which obturation technique do you use more often?

( ) Lateral compaction ( ) Carrier-based techniques (gutta- percha) ( ) Continuous Wave Compaction ( ) Warm Vertical Condensation ( ) Thermoplasticized injection technique ( ) Thermomechanical compaction with rotary ( ) Single Cone ( ) Other _____

7. Which sealer do you routinely use?

( ) Zinc oxide eugenol ( ) Epoxy resin ( ) Calcium hydroxide ( ) Glass ionomer ( ) Calcium Silicate-based Sealer ( ) Silicone Based-Sealer ( ) Other _____

8. If you use a "Bioceramic Sealer", which one do you prefer?

( ) Endosequence BC Sealer ( ) Endosequence BC Sealer Hiflow ( ) TotalFill ( ) BioRoot BC Sealer ( ) GuttaFlow ( ) Other _____

9. If you use a "Bioceramic Sealer", do you use Bioceramic coated gutta-percha cones?

( ) Yes ( ) No

Figure 1
The survey questionnaire.

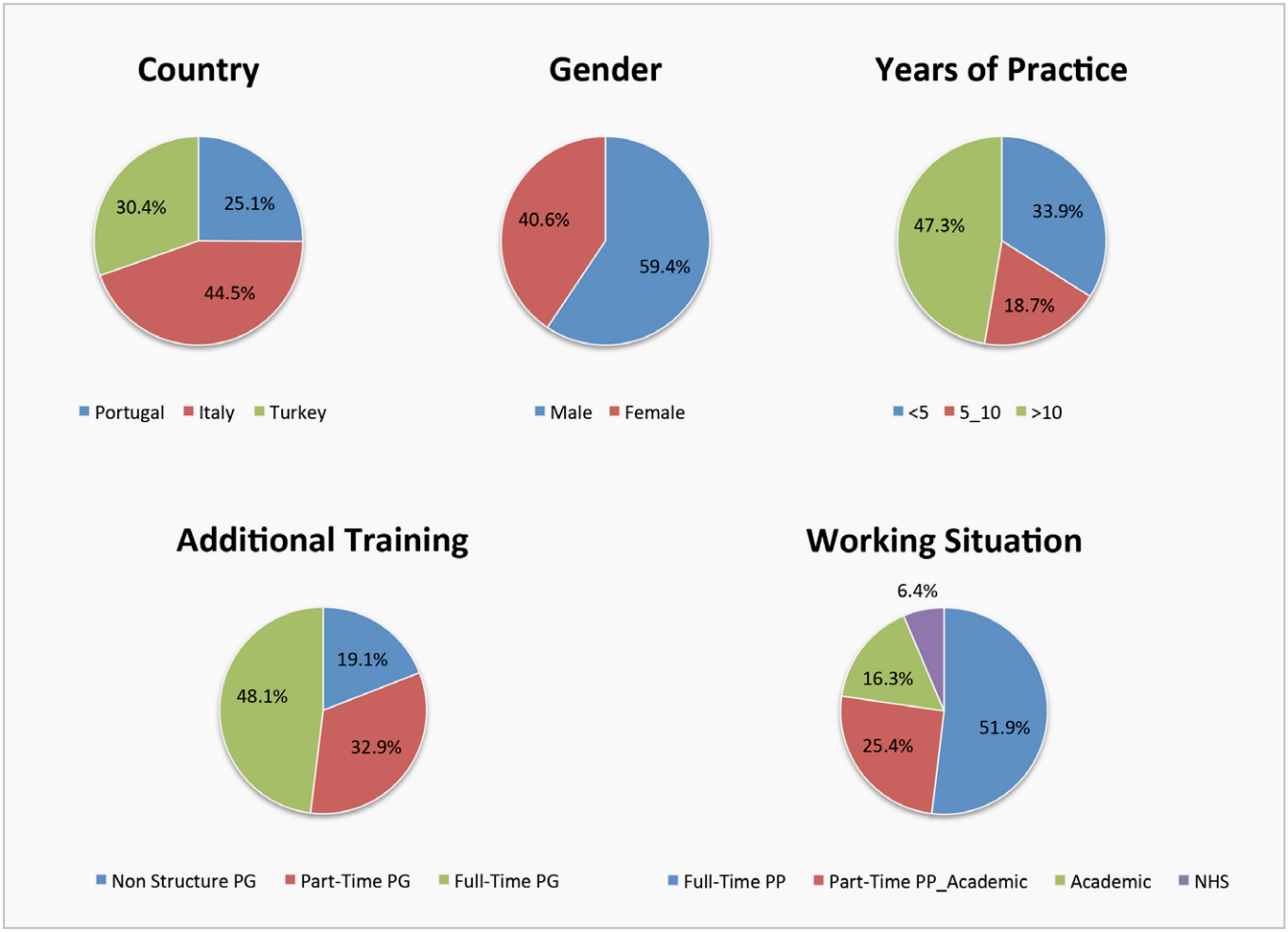

Figure 2
Demographic and professional data of the respondents according to gender, years of practice, additional training in endodontics and working situation.
PG-Post-Graduation; PP-Private Practice; NHS-National Health Service.

dents, root canal based sealer routinely used by the participants, the preferred calcium silicate-based sealer, and if the practitioner uses a "bioceramic" coated gutta-percha when a calcium silicate-based sealer is the choice. Related to "obturation technique", the different techniques were clustered into two major groups: warm and cold obturation technique. Carrier-based gutta-percha technique, continuous wave compaction, warm vertical condensation, thermoplasticized injection technique were included in warm obturation technique. Lateral compaction, thermomechanical compaction with rotary, and single cone were included in cold obturation technique.

The questionnaire was introduced into a Google forms® to ensure anonymity of the respondents. The questions were formatted as dropdown or selection options. Participation in the study was voluntary. The survey was available online from the 26th of December to the 26th of May.

Statistical Analysis

Data were collected and analyzed with SPSS® (version 24.0, IBM Corporation, Chicago, IL, USA). Descriptive statistics were given as frequencies (n) and percentages (%). A chi-square test of homogeneity and the Z Test were used to compare proportions of users of warm obturation technique or cold obturation technique associated with years of practice, additional training in endodontics, and working situation. A significance level of 0.05 was considered.

Results

The 32 countries represented within the 35 ESE full member societies were: Austria,

Belgium, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Republic of Ireland, Israel, Italy, Kosovo, Latvia, Lebanon, Lithuania, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spanish, Sweden, Swiss, The Netherlands, Turkey, United Kingdom. Belgium, Greece and Italy have each one two representative societies.

After the questionnaire was being available online for five months, 424 answers were obtained from 19 countries: Belgium, Czech Republic, Denmark, Estonia, Finland, France, Greece, Italy, Lebanon, Norway, Portugal, Republic of Ireland, Serbia, Slovakia, Slovenia, Sweden, The Netherlands, Turkey, United Kingdom. Most of the answers collected came from Italy (n=133), followed by Turkey (n=87) and Portugal (n=72). In order to do a reliable statistical analysis with comparable sub-groups, only the questionnaires from Portugal, Italy and Turkey were considered. A total of 292 answered were analyzed. Within these total participants, 9 of them answered not having any additional training in endodontics, and then were discarded. So, a total of 283 participants were considered to the statistical analysis.

The demographic and professional data of the respondents are represented in figure 2. The data came from three countries. From Portugal was registered 71 participants (25.1%), 126 from Italy (44.5%), and 86 from Turkey (30.4%). Within the respondents, 168 were male (59.4%) and 115 were female (40.6%). According to years of practice, 96 of the endodontic practitioners had been practicing for less than 5 years (33.9%), 53 of the respondents had been practicing for 5 to 10 years (18.7%) and 134 for over 10 years (47.3%). Considering the type of additional training in endodontics, 136 of the respondents had a full-time post graduation course in endodontics (48.1%), 93 had a part-time post graduation in endodontics (32.9%), and 54 had a non-structured training in endodontics (19.1%). Related to the working situation, more than half of the respondents (n=147) had been working full-time in private practice (51.9%). The other working situations were in descending order of frequency: part-time private practice/part-time academic (25.4%), academic (16.3%), and national health service (6.4%).

The preferences related to obturation (techniques, sealers, fillers) are represented in figure 3.

The warm obturation technique was practiced by 166 respondents (58.7%) and 117 practitioners preferred cold obturation technique (41.3%). Epoxy resin-based sealer was used by 148 of the respondents (52.3%), followed by zinc oxide eugenol (36.7%), calcium silicate-based sealer (8.1%), calcium hydroxide (1.4%), glass ionomer (1.1%), and silicone-based sealer (0.4%). Considering the question if the respondent used a "Bioceramic Sealer", which one was chosen, 114 (40.3%) of the respondents selected the BioRoot RCS (Septodont, Saint-Maur-des-Fossés, France), 79 (27.9%) selected the Endosequence BC Sealer (Brasseler, Savannah, GA, USA), 19 (6.7%) selected the TotalFill BC Sealer (FKG, La Chaux-de-Fonds, Switzerland), 10 (3.5%) selected the Endosequence BC HiFlow (Brasseler, Savannah, GA, USA), 18 (6.4%) answered "Others", and 40 (14.1%) answered not use at all the calcium silicate-based sealers. Within the respondents that used calcium silicate-based sealers, only 98 (34.6%) used bioceramic coated gutta-percha cones.

Years of Practice

A chi-square test of homogeneity was conducted between obturation technique (warm versus cold) and years of practice. All expected cell counts were greater than five. The practice of warm or cold obturation technique is dependent on years of practice as endodontic practitioner [$\chi^2(2)=40.7$; $p<0.001$]. The percentage of users of warm obturation technique was higher between the users with more than 10 years of practice (77.6%), and lower between the users with less than 5 five years of practice (36.5%) (figure 4). Inversely, the percentage of users of cold obturation technique was higher between the users with less than 5 years of practice (63.5%), and lower between the users with more than 10 years of practice (22.4%).

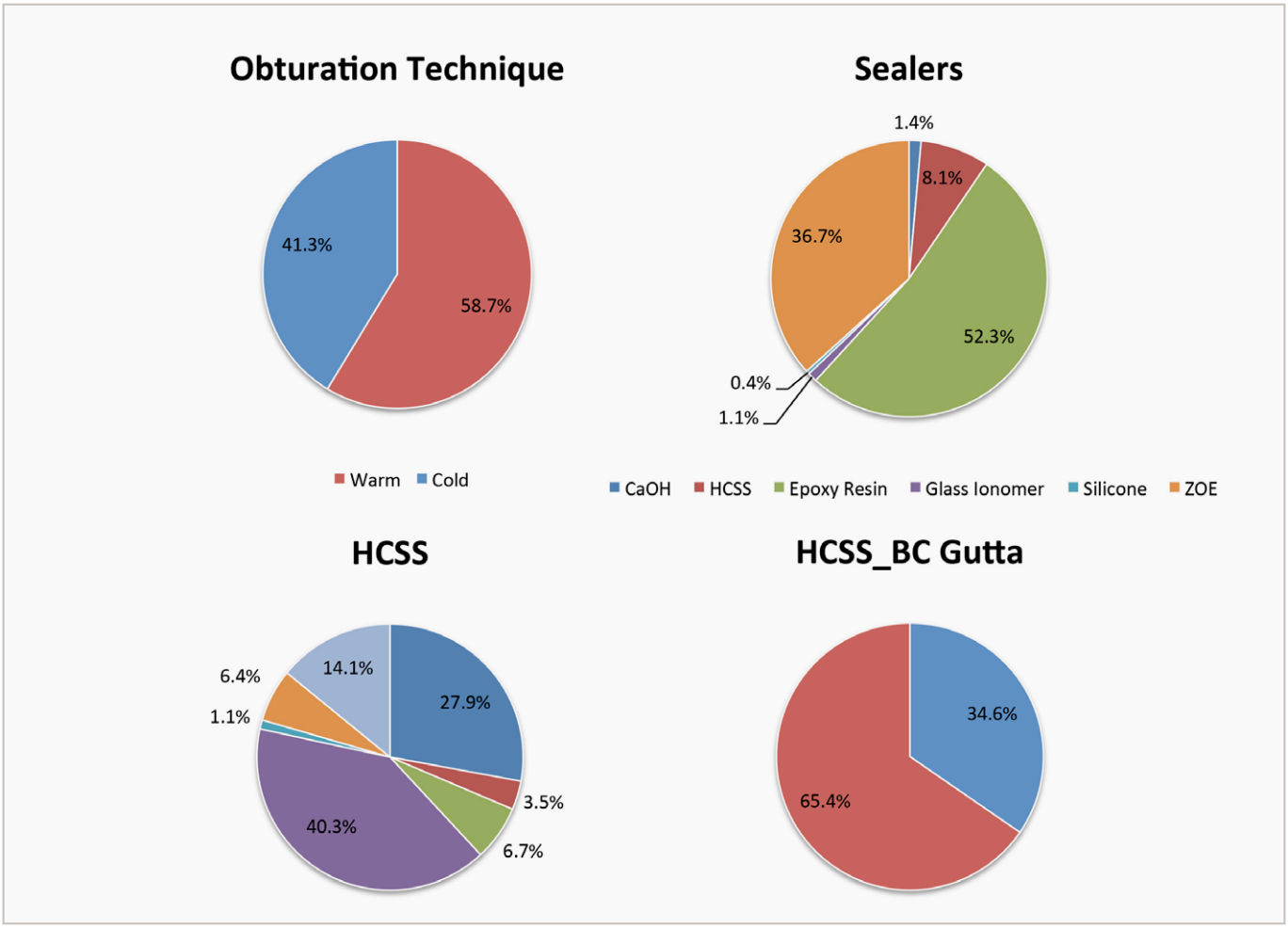

Figure 3
The preferences related to obturation (techniques, sealers, fillers) used by the practitioners.
HCSS-Hydraulic calcium silicate sealers; CaOH-Calcium hydroxide-based sealer; ZOE-Zinc oxide eugenol-based sealer; BC-Gutta- Bioceramic gutta-percha; ES_BC-Endosequence BC Sealer; ES_HF-Endosequence Hiflow.

Additional Training

A chi-square test of homogeneity was conducted between obturation technique and additional training in endodontics. All expected cell counts were greater than five. The practice of warm or cold obturation technique was dependent on the type of additional training [$\chi^2(2)=35.5$; $p<0.001$]. The differences were statistically significant within the 3 categories of additional training. Then, the choice of warm or cold obturation technique was dependent by additional training, even considered non-structure, part-time or full-time post graduation in endodontics.

The proportion of users of warm obturation technique was higher (83.3%) within the users that received a non-structured post graduation in endodontics, and lower (41.2%) between the users with a full-time post graduation as additional training in endodontics (figure 5). The percentage of users of cold obturation technique was higher between the endodontic practitioners with a full-time post graduation (58.8%), and lower within the respondents with a non-structured post graduation (16.7%).

Working Situation

The chi-square test of homogeneity was conducted between obturation technique and working situation. All expected cell counts were greater than five, and was showed association between all categories of working situation and the choice of warm or cold obturation technique [$\chi^2(3)=83.9$; $p<0.001$], except for part-time private practice with partial academic working situation, when the choice of warm or cold obturation technique was not dependent by the working situation.

The full-time private practice was the working situation with higher proportion of warm obturation technique users (78.2%), and the academic working situation had a lower proportion of warm technique users (4.3%). Within the academics, 95.7% selected cold obturation technique (figure 6).

Discussion

Several studies have investigated the attitudes of general dental practitioners towards various aspects of endodontic treatment, for example, in United Kingdom (8), Belgium (9), Nigeria (10), Sudan (11), Australia (12), Denmark (13), USA (14), Sweden (15), Turkey (16), Iran (17), and Saudi Arabia (18). However, none of them only focused on the obturation preferences. This way, this study was important to clarify the obturation trends, specifically the preferred use of the warm obturation technique versus the cold obturation technique related to years of practice, additional training in endodontics and working situation.

One of the limitations of this survey is related to a representation of only three European countries, and then cannot be a truly representative of filling trends in Europe. Within the country representative from all ESE societies we assisted of an uneven low number of respondents for

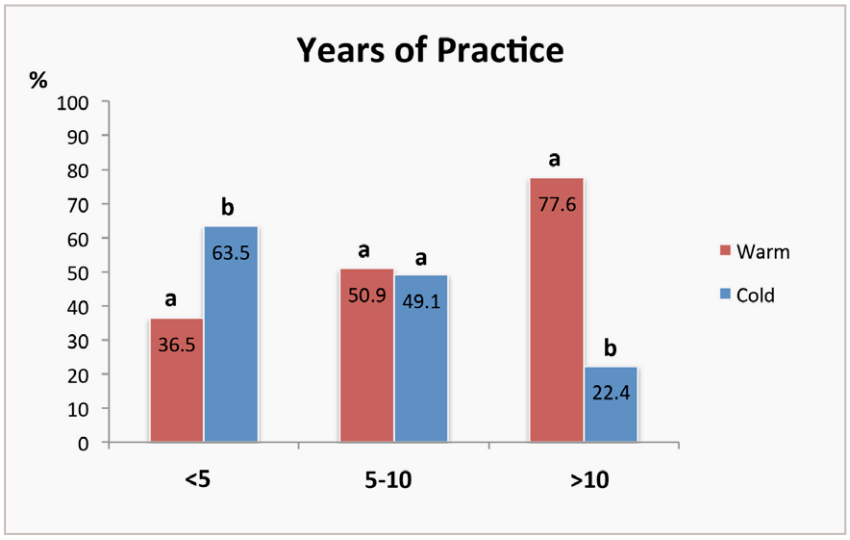

Figure 4
Proportion of participants (%) who perform warm obturation technique or cold obturation technique within each category of years of practice: <5 less than 5 years of endodontic practice; 5-10 five to ten years of endodontic practice; >10 more than 10 years of endodontic practice.
Different letters show statistical significant difference (p<0.001).

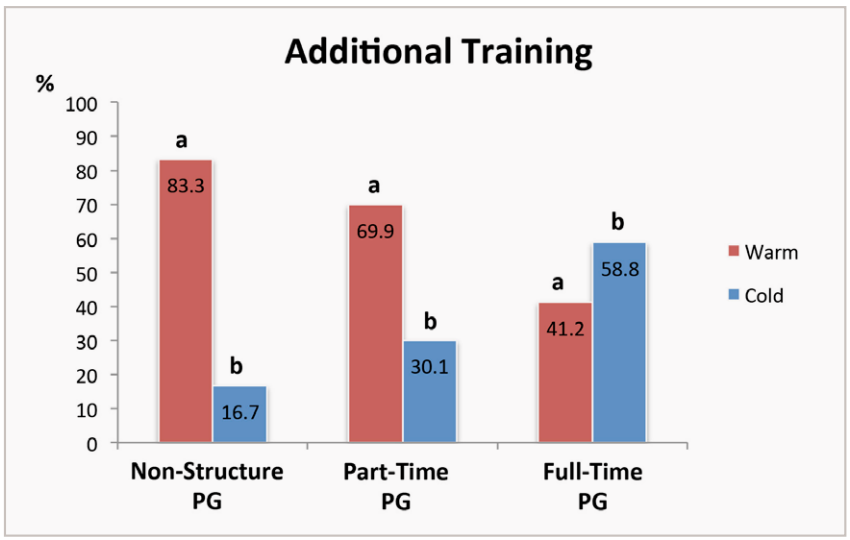

Figure 5
Proportion of participants who perform warm obturation technique or cold obturation technique related to additional training in endodontics.
PG=Post-Graduation.
Different letters show statistical significant difference (p<0.001).

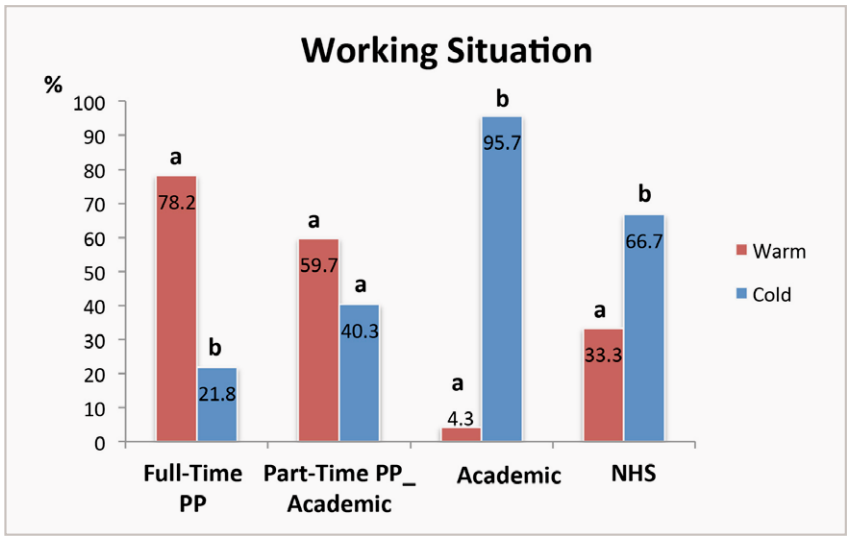

Figure 6
Proportion of participants who perform warm obturation technique or cold obturation technique related to working situation.
PP=Private Practice; NHS=National Health Service.
Different letters show statistical significant difference (p<0.001).

each country. Although the 32 countries represented within the 35 ESE full member societies were asked to participate, some countries didn´t attend based on the explanation that don't have the policy to deliver this kind of initiatives among its members. If all the answers would be considered, an unbalance statistical analysis in the groups would be present. Then, just answers collected from the most reliable countries representation were considered. From Portugal were collected 71 answers, and from Italy and Turkey, 126 and 86, respectively. In 2019, the Portuguese society had 230 endodontic practitioners associated. The Italian societies and the Turkish society had about 1001 and 450 endodontic practitioners associated, respectively. Although these numbers may present variability over the years, related to 2019, the response rate from Portugal was 30.9%, and from Italy and Turkey was 12.6% and 19.1%, respectively.

The strategy applied in this work was a web-based survey, introduced into a Google forms® to ensure anonymity of the respondents. The increase in the use of web-based surveys can improve response rates by achieving higher levels of participation and enhancing the statistical power of the results (19). Investigators have reported that web- or internet-based surveys have greater effectiveness over traditional methods of data collection when used by specific populations who regularly use the internet in their daily lives (20). However, the main drawback of this web-based survey was the low response rate relative to the large number of professionals who receive the questionnaire. A low response rate to a web-based survey does not entail a nonresponse error; however, a reduction in the sample size could result in a higher sample error (21, 22).

This questionnaire comprises a specialized cohort, with additional training in endodontics. Almost half of the respondents had a full-time post graduation in endodontics (48.1%). The warm obturation technique was the most used among the participants (58.7%). The cold obturation technique had a proportion of 41.3%. The various obturation techniques presented in questionnaire were clustered into two major groups: warm versus cold technique. This allowed a more balanced groups, in order to do a more reliable statistical comparisons. Within the warm obturation technique, the continuous wave of compaction represented the most used warm technique (72.3%). Within the cold obturation technique, the 2 techniques most used were the lateral compaction (57.3%) and the single cone technique (34.7%). Considered the totality of participants (N=283), the single cone technique had a proportion of users of 15.2%. A study conducted between the Flemish general

dentists (9), described the single cone as the technique used by 16.0% of the respondents, which it´s corroborated with this work.
In the majority of surveys with general dental practitioners, the lateral compaction was the most popular obturation technique. Indeed, the obturation trends could change among the general dental practitioners. Another study, understanding the adoption of new endodontic technology amongst 692 Danish general dental practitioners, registering that 65% never used warm gutta-percha (13). The percentage of use of lateral compaction varies among the studies: 81% (18), 65.8% (9), 40% (14). Current trends in endodontic treatment by general dental practitioners were also reported in a United States national survey (14). In that study, 40% of general practitioners reported using cold lateral compaction; however, 54% used various warm obturation techniques. This last percentage corroborates the percentage of warm obturation technique registered in the present study.
Over the years, numerous methods have been advocated to filling the prepared root-canal system, each with its own claims of easy, efficiency or superiority. However, there are few data on the influence of obturation technique on treatment outcomes. A meta-analysis reported that a higher rate of overextension was associated with warm gutta-percha obturation compared with cold lateral compaction, but other factors such as postoperative pain prevalence, long-term outcomes, and obturation quality were not different (23). Few studies have been concerned with factors that influence the quality of root canal treatment, like factors related to root canal obturation. It might be assumed that such factors will be related not only to the individual endodontic practitioner (knowledge, attitudes and skills), but also to the context in which the practitioner works. For example, the remuneration system, time pressure, working conditions and patient expectations.
This could explain the result in this study, where practitioners who are working in the public service revealed more practice of cold technique (66.7%), contrasting with 78.2% of endodontic practitioners with a full-time private practice, which adopt warm obturation technique most frequently. Surprisingly, regarding a full-time academic situation, 95.7% of endodontic practitioners selected a cold obturation technique. Indeed, lateral compaction is taught and practiced worldwide, serving as the gold standard against which new techniques must be compared (4).
This could explain that probably the most taught technique could be the one most applied by the academic endodontic practitioners themselves. Indeed, the working situation had a strong association with the type of obturation technique selected (warm versus cold). When it was observed a statistical parameter likes the Phi nominal measure, the value of association between warm or cold obturation technique and years of practice, additional training in endodontics, and working situation, 0.379, 0.354, 0.545 was obtained, respectively.
Within the three values, the stronger association is related to working situation (0.545), which revealed a high dependence on obturation technique and working situation. This could explain the surprisingly proportions of warm technique users when a full-time post graduation was done. Indeed, when the endodontic practitioner had an additional training like a full-time post graduation, 41.2% of participants selected warm obturation technique, contrasting with 83.3% of practitioners with a non-structured post graduation, who selected warm technique. Probably, in a more deeply and complete additional training, like a full-time post graduation, it will be expected to be associated with a more proportion of warm technique users, which are more technique sensitive, and with a higher learning curvature. However, a possible explanation could be done crossing the information between the additional training and the working situation.
Within the participants who did non-structured post graduation training, 94.4% had a full-time private practice. However, participants who did full-time post grad-

uation training, just 28.7% had a full-time private practice. The participants who did a full-time post graduation more frequently were associated with an academic working situation or other public service, where financial resources could be a limitation to select a more expensive equipment like the one applied to warm obturation technique.

The association between the years of practice as endodontic practitioner, the additional training in endodontics, and the working situation have a dependent relationship with the choice of a warm or a cold obturation technique ($p<0.01$). Practitioners with more than 10 years of practice in endodontics selected most often the warm obturation technique (77.6%). This percentage dropped to 36.5% between the respondents who had graduated less than 5 years. Not because the "young" endodontist has less skills and less academic differentiation (participants who answered that have less than five years of practice, 55.2% have a full-time post graduation endodontic training), but probably because the "young" endodontist are likely to have less economic autonomy to invest to their clinical private practice. Indeed, the lateral compaction is a relatively simple and versatile technique that does not require expensive equipment like continuous wave technique does. Also, the single-cone technique, which is becoming increasingly popular since it is being associated as an easy handling and straightforward technique, low cost, less operator-dependent and associated with a short procedure time (24, 25). In this technique more emphasis is placed on the sealer and not primarily on the gutta-percha cone. However, a higher sealer volume inside the root canal space may negatively influence the seal, as most available sealers tend to shrink upon setting (26).

As a result, single cone technique combined with conventional sealers was deemed inappropriate, and up until now, it was recommended to maximize the gutta-percha volume and minimize the sealer thickness (27), using thermoplasticized gutta-percha obturation techniques. However, in this study, the epoxy resin-based sealer was the most used sealer (65.1%), even when the single cone technique was applied. Just 16.3% of the practitioners used calcium silicate-based sealers in a single cone technique.

The principal reason of using single cone technique by a more specialized endodontic practitioner could be more related to association between the single-cone technique and the biologic benefits of calcium silicate-based sealers. Since mineral trioxide aggregate development, silicate-based materials are widely used in endodontic procedures because of their excellent biological properties (28). Considering the preference of calcium silicate-based sealers, in this study the BioRoot RCS sealer was the most chosen (40.3%), followed by Endosequence BC Sealer (27.9%), and TotalFill BC Sealer (6.7%). Even with a more easily way of use, like a premixed sealer in a syringe with a capillary tip, easy to introduce into the canal, a manual mixing of calcium silicate sealer, like BioRoot, was preferred. Probably related to a high disposability in a European endodontic market. Endosequence BC and TotalFill have the same composition (29). However, the first is most commercialized in United States and TotalFill in Europe. If we grouped together the use of Endosequence BC and TotalFill, the proportion corresponded to 34.6%. The Endosequence Hiflow represented a low proportion (3.5%) of calcium silicate-based sealers used, probably because it´s the most recently calcium silicate sealer launched to the market, which has yet a few independent studies (30-32).

This study corroborates the finding of some clinical inconsistency on using of calcium silicate-based sealer. In this work, even considering just the single cone practitioners, epoxy resin-based sealer was preferably chosen (65.1%). Also, the practitioners who selected the calcium silicate-based sealers only 34.6% selected bioceramic coated gutta-percha cones. Indeed, a recently international survey was published to gain insight on the current clinical usage of "bioceramic" root canal sealers by general dental practitioners and endodontic practitioners, and

to determine if "bioceramic" root canal sealer clinical application is in accordance with the best available evidence (33). The authors highlighted wide variation in the clinical practices, which are not often in accordance with the current literature on "bioceramic" root canals sealer. This inconsistency implies to provide further clarifications and better standardization on "bioceramic" root canals sealer clinical application.
Other studies about obturation trends should be carried out to reach more representation from each European country. It is hoped that this baseline information providing a snapshot of current endodontic practice by some members of the endodontic societies, and can serve as a launching point for further, more in-depth investigations of particular topics of interest. It will be interesting in the future, to check whether the single-cone technique and trends of calcium silicate-based sealers will increase in popularity in Europe, the correct clinical application of these types of sealers and the possible impact on the outcome.

Conclusions

The results of this survey found that standard techniques and materials remain to be used by the practitioners, like a cold lateral compaction, although the warm obturation technique was the most preferred within the participants. However, new materials and techniques, like calcium silicate-based sealers and the reconsidering single cone technique, are growing in popularity amongst endodontic practitioners. Individual factors like years of practice, additional training in endodontics, and working situation influenced the obturation technique choice.

Clinical Relevance

Among endodontic practitioners who participated in this study, the warm obturation technique is still the most used. However, the selection between warm or cold obturation technique is dependent by years of clinical practice, additional training in endodontics and working situation. The single cone associated with calcium silicate-based sealers is an emerging technique. However, when it is adopted, the core material most selected is gutta-percha non bioceramic.

Conflict of Interest

The authors deny any conflict of interest.

Acknowledgements

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