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Studies in Endodontics

M. Sadegh Namazikhah, DDS, MSEd

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FEATURES

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Perception or Reality?

Jack F. Conley, DDS

For many years, leadership in the dental profession has taken great pride whenever results of public opinion surveys have shown dentistry to receive high marks in public esteem. For example, a review of our files confirms that a poll conducted in the late 1980s by the Gallup Organization rated dentistry as the second most highly respected profession in America. That report, which was utilized by the Select Program of the American Dental Association and the American Association of Dental Schools to attract highly qualified individuals to careers in dentistry, noted that dentists were rated higher in terms of honesty and ethical standards than physicians, clergy, or lawyers.

If one can place any validity in opinion polls, the times have been changing. In 1998, when the same poll was conducted covering 25 professions, Dentistry ranked fourth. Given that it is an "opinion" poll, a drop of two places over 10 years is probably not significant. Considering that dentistry had been ranked higher than the clergy and physicians a decade ago, what might have been most significant about the 1998 poll is that clergy (second) and physicians (third) now ranked ahead of dentists.

However, the 1999 poll is the one that gives us the most disturbing reason to reflect on our public image. Twenty occupations not previously listed in this poll were included to bring the number of professions in this ranking to 45. In this ranking, dentistry dropped to ninth. Physicians and clergy also lost some ground, but only to fourth and sixth, respectively. In this poll, nurses, veterinarians, and teachers, which were among the newly added professions, placed above dentistry. Even taking that into consideration, dentistry has lost four places since the 1980s. It seemed ironic to see that police, despite scandals in New York and Los Angeles, were still one notch above dentists at eighth. Perhaps that ranking will decline in the next poll!

Background information on this poll, both past and present, indicates that image is based upon honesty and ethical standards. Organized dentistry has always placed great importance on its Code of Ethics. Many of our colleagues over time, by word and deed, have demonstrated their support of our professional standards, encouraging others to follow their lead. However, the results of these most recent Gallup polls are certainly no surprise to many colleagues, some of whom have sometimes complained bitterly that dentistry has been experiencing a decline in adherence to professional ethical standards.

This latest Gallup poll does raise the question as to whether it is a valid monitor of a downward trend in the adherence to professional ethics by dentists in the past decade. Is public opinion too heavily influenced by the emotions of media events to be reliable, leading to the perception that dentists as a professional group are less ethical than in reality they are? For example, is public opinion swayed more by emotional television reports tending to be critical of dentistry on topics such as waterlines (the dentists' "Dirty Little Secret"), the amalgam controversy, and deaths of children under sedation or anesthesia? It does need to be said that on the positive side, dentistry has done a great deal to continue to earn public trust through activities such as prevention and infection control practices. However, an observation here is that the perception of dentistry's image is probably more easily shaped by negative emotional issues than by positive professional efforts.

We have had discussions with many dentists and nondentists regarding honesty and ethics in society at large. There seems to be general agreement that there was a negative trend in the past decade. Has a decline in dental ethics been any more significant than, or merely reflective of, a decline in ethical behavior society? We don't have the answer to that question, although our belief is that changes in dentistry only mirror those in society at large.

Finally, let's consider two trends in dental practice that help to shape the attitudes that patients develop about dental health professionals. If we fail to properly educate patients about their dental benefits, do some individuals lose trust or believe that we have done something wrong if their plan denies or reduces benefit payments? And, what about the significant marketing of cosmetic dentistry? We have seen opinion pieces by nondentists who have expressed the attitude that the aggressive marketing of cosmetic dentistry is nothing more than a vehicle for economic greed by some practitioners.

These trends, coupled with the exposure to negative "dental issues" in the media, may help to explain why dentistry's public image has appeared to fall in the last decade. It seems that all of these influences together have reduced the public's perception of dentistry's public image. And, perception becomes reality.

Public opinion polls such as those conducted by the Gallup Organization may not have great value or validity. Their importance or the scientific process used to develop them could be questioned. But for a profession that has traditionally taken pride in its ethical standards, the 1999 Gallup poll, without question should, as a minimum, serve as an important wake up call.

Pickin' and Grinning

Humans were using toothpicks up to 1.8 million years ago, according to research on a fossilized tooth done at the University of Arkansas.

Microscopic scratches were found on a tooth discovered by noted anthropologist Mary Leakey in the Olduvai Gorge. The strange grooves are consistent with toothpick use, according to Peter Ungar, an associate professor of anthropology at the school.

He and his colleagues suspect that the marks were left by pieces of bone or grit on a stick that was used for cleaning teeth. Ungar believes the practice became common about the time ancient humans started eating meat.

Eat Your Way to Better Dental Health

By David G. Jones

When people eat food or sip a drink containing commonly used preservatives, they may be unconsciously improving their oral health in a way they didn't expect.

That's the news from researchers at the University of Rochester, New York, Medical Center who presented their findings at the April 8-9 annual meeting of the International Association of Dental Research. Their studies, performed at of one of the world's leading programs in dental research, showed that common food preservatives such as benzoates and sorbates enhance the caries-protective action of fluoride.

One of the researchers, microbiologist Robert Marquis, PhD, performed laboratory studies that showed many food preservatives seem to mimic fluoride's anticaries effects.

"We found that food preservatives inhibit bacteria in much the same way that fluoride does in bacteria like Streptococcus mutans," he says. "It puts protons, basically weak acid, into its cells. The bacteria try to move the acid out of their cells because their enzymes are not acid-tolerant."

Marquis says the preservatives and fluoride work to push bacteria to exhaustion, using molecular action to continually lower the pH within bacteria, while the bacteria constantly pumps it back out. Losing energy, the bacteria's cells stop producing the caries-causing acid.

"Fluoride and preservatives prevent the bacteria from acidifying the plaque and causing caries," Marquis says. "The bacteria are still there, but they're not causing damage."

Fellow Rochester researcher William H. Bowen, BDS, PhD, took Marquis' research a step further, conducting studies to investigate the effects of food preservatives and fluoride on caries in rats.

"They're an excellent model because they get decay just like humans do," says Bowen, a Welcher Professor of Dentistry and a member of the National Institute of Medicine. "And the same substances that prevent caries in rats stop them in people."

In one study, Bowen's team measured the number of cavities in rats from several groups: some received fluoride, some received benzoates, some received neither, and some both. All the rats that received fluoride in their diets had far fewer cavities than those that didn't. But fluoride's effect was stronger in animals that also received benzoates or sorbates.

Benzoates are used in a wide range of foods to help keep the food supply safe from bacteria and other toxins. Benzoates also come from natural sources, including cranberries, prunes, and cinnamon. Sorbates, the other preservative used in the study, are used in many common items such as lunchmeats, mayonnaise, dried fruits, and candy bars. They may one day be used in oral care products such as toothpaste to increase fluoride's effectiveness, according to the researchers.

"We would like to test preservatives initially in rats and then on humans to see if the studies work out as we anticipate," Bowen says. "We certainly think there's every prospect of ending up with commercial products."

Marquis says that an eventual goal of the research is to develop the optimal weak acid as an anti-caries agent.

"That's desirable, because many people feel they're getting too much fluoride," Marquis says. "Our view is that if we can reduce the amount of fluoride in toothpaste by incorporating weak acids into it, we may reduce the incidence of fluorosis."

Bowen says that he and Marquis are not questioning the effect and safety of fluoride; they're looking for methods to enhance its effectiveness.

"When something like fluoride works, people get excited and sometimes don't look beyond the obvious," he says. "There are a lot of things going on in our food supply that provide oral health benefits that haven't occurred to people."

Dennis Mangan, PhD, chief, infectious diseases and immunity branch of the National Institute of Dental and Craniofacial Research, was involved with the grant that supported the work. He also says that there are many factors influencing what's happening in the oral cavity.

"We know fluoride has certain effects, but don't completely understand the other influences food or other things have," he says. "This is an example of research that shows us how intricate or complex the oral cavity is. It's not a static environment where only one factor like fluoride affects it. When we ingest anything there are multiple influences."

Noted fluoride research expert Gary Whitford, PhD, DMD, Regents' Professor at the Medical College of Georgia, wasn't surprised by the research results.

"If any agent were capable of inhibiting bacterial acid production, it would be expected that the effect would be additive to fluoride's. That doesn't surprise me."

Whitford says that caries is a multifactorial disease that we don't yet fully understand.

"There are a number of things we still don't understand about its cause and factors that influence its development," he says. "There are a variety of things in the diet that could add to the effects of fluoride, and in future years as they are identified they could improve the situation."

Marquis and Bowen have published their work in abstract in the Journal of Dental Research and are writing a paper that they expect to have published later this year.

Bowen says that preservatives are a serendipitous oral health benefit of our diet today.

"But you can't rely only on serendipity to protect your teeth."

Large Study Supports Smoking and Cleft Palate Link

Women who smoke during pregnancy are more likely to have a baby with cleft lip or palate than are nonsmoking women, according to a large study involving information from the U.S. Natality database.

The Natality database from 1996 and a case-control study design were used to investigate the association between maternal smoking during pregnancy and having a child with cleft lip or palate.

The records of 3.8 million live births from the database were extracted to obtain cleft lip and palate cases and random controls.

"In about 4 million births in the U.S. in 1996, 13 percent of mothers reported to have smoked during pregnancy," said Dr. Kevin Chung, lead author of the study. "This translates to a huge public health issue."

More than 2,200 cases of cleft lip or palate were recorded in babies born to the women who smoked.

Women who smoked were up to 70 percent more likely to have a baby with cleft lip or palate. Even after the data was adjusted for other factors prevalent in smoking women -- such as hypertension and lower education -- women who smoked 1 to 10 cigarettes per day were 30 percent more likely to have children with cleft lip or palate.

Antimicrobials Found in Chewing Sticks

For thousands of years, much of the developing world has been preventing cavities and gum decay by using chewing sticks from the root, stem, or twig of local trees and shrubs.

Researchers have now isolated the antimicrobial agents in some of these chewing sticks that they believe act to kill bacteria in the mouth and surrounding the teeth. Their findings were published in the March 20, 2000, issue of the Journal of Agricultural and Food Chemistry.

Researchers at the University of Stellenbosch in Tygerberg, South Africa, specifically looked at the properties of one particular chewing stick in Namibia commonly referred to as "muthala." An earlier oral health survey of more than 2,000 Namibians had indicated that the 20 percent of the population that use muthala had lower cavity rates than those who did not use any dental hygiene method.

The sticks are prepared by cleaning the wood, removing the bark, and cutting and bundling them into usable sizes that are sold in local markets. Over time, the sticks become frayed by chewing, which serves to clean teeth not only by passively releasing such compounds but also by active repeated mechanical use in brush-like fashion.

In the current investigation, the researchers were able to isolate four compounds found in the pencil-sized chewing sticks that demonstrated an ability to inhibit oral bacteria.

Sleep Apnea Associated With Hypertension

An association has been found between sleep-disordered breathing and hypertension in a large multicenter study, according to an article in the April 12, 2000, issue of the Journal of the American Medical Association.

F. Javier Nieto, MD, PhD, from Johns Hopkins School of Hygiene and Public Health in Baltimore and colleagues reported on the association between hypertension and sleep-disordered breathing, which includes sleep apnea (a complete or almost complete cessation of airflow during sleep often characterized by snoring). The researchers reported on data from 6,132 participants 40 years old and older who participated in the Sleep Heart Health Study, a multicenter study that recruited patients with sleep apnea from other studies in order to examine the associations between sleep apnea and cardiovascular conditions.

The researchers found that the prevalence of hypertension (defined as resting blood pressure at least 140/90 or use of antihypertensive medication) increased as average sleep-disordered breathing episodes per hour increased. Participants in the category of highest frequency of breathing disorders (30 or more apnea-hypopnea index episodes per hour) had a higher risk (adjusted odds ratio of 1.37) of experiencing hypertension than those in the lowest category (less than one and a half apnea-hypopnea index episodes per hour). The crude rates of hypertension ranged from 43 percent for those in the lowest apnea-hypopnea index category (less than 1.5 per hour) to 67 percent for those in the highest apnea-hypopnea index category (30 or more per hour).

"After controlling for the main potential cofounders (age, sex, BMI [body mass index] and other measures of adiposity [fat just beneath the skin]) as well as for other potentially relevant variables (alcohol intake, smoking), high levels of [apnea-hypopnea index] or sleep time below 90 percent oxygen saturation were associated with greater odds of hypertension in a dose-response fashion [the higher the levels of (apnea-hypopnea index) or sleep time below 90 percent oxygen saturation the higher the blood pressure levels]."

The researchers used the apnea-hypopnea index to assess sleep-disordered breathing. The apnea-hypopnea index included the average number of apnea episodes plus the average number of hypopnea episodes per hour of sleep. Hypopnea was defined as a 30 percent or greater decrease in airflow or a 30 percent or greater decrease in chest and abdomen movement accompanied by a 4 percent or greater decrease in oxygen saturation in the blood.

The researchers measured apnea-hypopnea index using a polysomnography during a one night home visit to measure a number of factors including airflow and chest and abdominal movement. The participants also completed a self-administered questionnaire about sleep habits that included questions about awareness of a history of snoring, awareness of sleep apnea, awareness of treatment for sleep apnea and experience of sleepiness. The researchers also measured the number of arousals from sleep per hour and the percentage of sleep time where the oxygen saturation was below 90 percent.

Honors

Eddie K. Hayashida, DDS, MBA; Susan A. Bittner, DDS; and Frank A. Brucia, DDS, have received the 2000 Medallion of Distinction Award from the University of the Pacific School of Dentistry. (photos of all)

Craig S. Yarborough, DDS, MBA, has been appointed associate dean for institutional advancement. (photo from Jan. Journal -- chair of Sessions council)

Robert L. Merin, DDS, MS, will be installed this month as president of the California Society of Periodontists. (photo)

Mahmoud Torabinejad, DMD, MSD, PhD, has been re-elected treasurer of the American Association of Endodontists.

Studies in Endodontics

M. Sadegh Namazikhah, DDS, MSEd

AUTHOR

M. Sadegh Namazikhah, DMD, MSEd, is the acting chairman of the Endodontics Department and director of the Advanced Endodontic Program at the University of Southern California School of Dentistry. He is also the chairman of the ad hoc Interorganizational Affairs Committee for the California Dental Association and the chairman of the Membership/Ethics Committee of the Los Angeles Dental Society.

The opportunity to lend direction to this issue of the *Journal of the California Dental Association* presents at an exciting time in both the field of endodontics and the focus of the University of Southern California Endodontic Program. It is with great honor and satisfaction that this department can help shape the future of a wonderful field of dentistry. With the continued technological improvements in endodontics, the need for basic scientific principle becomes even more crucial. Diligent research and a thorough understanding of historical literature must remain the backbone of the practitioner's technique. It is because of this ideal that the Endodontic Department at the University of Southern California School of Dentistry has embarked on a long-term commitment to research and literature.

My goal for this issue is to address some of the current questions and concerns that have recently arisen in the field of endodontics. I feel that the *Journal of the California Dental Association* is an ideal forum to achieve that goal because it shares our department's commitment to research and literature.

The basic principles in endodontic treatment will never change. A proper access allowing a thorough cleaning and shaping of the canal system that, in turn, allows for an obturation that is contained within the canal system and prevents bacterial contamination is the ideal. Each article presented in this issue will address some feature of this endodontic ideal.

One of the articles examines concerns over where to position the gutta percha fill at the root end. With recent insurance company dictations and historical literature guidelines offering opinions as to this matter, the need for an understanding of this aspect of obturation is imperative for the practitioner.

The second article addresses one of the hottest technological advancements in the field of endodontics -- rotary instrumentation. As with any technique in dentistry, a thorough scientific and practical understanding must be achieved by the practitioner. For this reason, the article takes an original approach in determining the value of rotary instrumentation by comparing a standard rotary technique to the traditional technique in the hands of the less experienced practitioner.

The third article looks at another aspect of obturation -- gutta percha sterilization. As we strive for an aseptic root canal therapy, it is logical that our obturation material must be aseptic.

The final article compares three obturation techniques. In this article, Simplifill, Thermafill, and traditional lateral techniques are examined.

My hope is that these original articles will help provide the practitioner with a solid scientific background to help him or her choose a proper endodontic technique for the 21st century.

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An In-Vitro Comparison of the Radiographic and Actual Gutta-Percha Terminus

M. Sadegh Namazikhah, DMD, MsEd; Mojgan Ghiai, DDS; Matthew J. Parkin, DDS; Lawrence Puccinelli, Jr., DDS

ABSTRACT The purpose of this study is to investigate the difference between the radiographic gutta-percha terminus and the actual gutta-percha terminus of human molars by comparing radiographic obturation results with actual obturation results. Forty maxillary palatal roots and 50 mandibular distal roots were randomly selected from a population of 540. They were then mounted in stone and radiographed. Conventional endodontic therapy was completed using stainless steel K-files and lateral condensation. Each radiographic gutta-percha terminus was evaluated under 4.5 x magnification by three examiners following the completion of root canal therapy. These results were recorded. Each tooth was then removed from its mounting, and the actual gutta-percha terminus was evaluated under 4.5 x magnification. These results were recorded and compared to the radiographic gutta-percha terminus results. In all 90 teeth examined, the actual gutta-percha terminus was equal to or longer than the radiographic gutta-percha terminus. In the 50 mandibular distal roots, the actual gutta-percha terminus averaged 0.645 mm longer than the radiographic gutta-percha terminus. In the 40 maxillary palatal roots, this difference measured 0.6375 mm.

AUTHORS

M. Sadegh Namazikhah, DMD, MSEd, is a professor of clinical dentistry, acting chairman of the Endodontic Department, and director of the Advanced Endodontic Program at the University of Southern California School of Dentistry.

Mojgan Ghiai, DDS, is a second-year resident in the Graduate Endodontic Department at USC.

Matthew J. Parkin, DDS, is a second-year resident in the Graduate Endodontic Department at USC.

Lawrence Puccinelli, Jr., DDS, is a second-year resident in the Graduate Endodontic Department at USC.

In endodontic therapy, the apical constriction has long been recognized as the anatomical location to provide the barrier between the root filling material and the apical tissues. Historical studies including Kuttler in 1955,[1] Green in 1956[2] and 1960,[3] and Chapman in 1969[4] have examined the intricacies of the apical portion of the root. Thus, the ideal root canal filling would completely fill the obliterated pulp space and provide a seal at the dentinocemental junction. However, the anatomical location of the apical foramen is not exclusively located at the anatomical root apex.

In Seltzer's 1969 study on periapical tissue reactions to root-filled teeth, optimum tissue results were obtained when root canals were instrumented and filled short of the apices of the teeth. Seltzer claimed that repair was delayed in the group of teeth in which the canals were overfilled.[5]

Palmer and colleagues stated in a 1971 study that the proper location of the apical foramen could not be discerned from a radiograph.[6]

In a study of 100 mandibular molars in 1958, Green determined that the average distance between the major canal foramina and the apex of the distal root was 0.43

mm. In some instances, this discrepancy measured to be as great as 3 mm.[7]

In a follow-up study by Green in 1960,[3] 700 maxillary and mandibular posterior teeth were evaluated. Approximately 50 percent of major foramina did not open at the anatomical apex. Those that did not open at the apex ranged from eccentric position to 2 mm from the apex.

In 1972, Burch and Hulen found that the frequency of deviation of the major foramen from the anatomical apex was found to range from 78.0 percent in maxillary incisors to a high of 98.9 percent for mandibular distal roots. The largest deviation was found to occur on distal mandibular molar roots. This average was 0.78 mm.[8]

In 1986, Abou-Rass stated that in posterior teeth the distance between the apical foramen and the root end averages 0.5 to 1.0 mm. Abou-Rass added that in 70 percent of molars, this foramen is not at the root end.[9]

These discrepancies between the anatomical and radiographic apex in the above and other studies is the motivation for this study. The purpose was to demonstrate that the radiographic representation of the root fill can be quite different from the anatomical location of that root fill.

Materials and Methods

Five hundred and forty extracted mature human first and second maxillary and mandibular molars were endodontically treated in the preclinical laboratory by second-year University of Southern California dental students. These teeth were mounted in a mixture of yellow stone and orthodontic acrylic with a 2 mm ball of red rope wax to allow for apical overfill The teeth were radiographed and accessed with a chamfer diamond bur. Working lengths were determined radiographically with #15 K-files in the canals. The canals were preflared with Gates-Glidden burs and cleaned and shaped using a standard crown-down technique. Irrigation was maintained with 5 percent sodium hypochlorite, and endo dilator was used if indicated. Canals were dried and coated with AH26 cement. The students were instructed to fill the canals 0.5 millimeters short of the radiographic apex. Radiographs were taken at various intervals during the treatment.

From these 540 teeth, 40 maxillary palatal roots and 50 mandibular distal roots were selected for the study by three second-year endodontic residents and the director of the advanced endodontic program. Teeth were eliminated for the following reasons: gross overfill or underfill, separated instruments, perforations, transportations, excessively poor technique, or damaged teeth from cast removal.

The 90 roots were numbered and evaluated independently by each of the three residents on the basis of root end fill discrepancy from the radiographic apex under 4.5 x magnification. An average was taken from the three measurements for each tooth. The range of these data was from 1.5 mm underfill to 0.5 mm overfill.

Once these data was recorded, each tooth was carefully removed from its cast and placed in a coin envelope with the number of the tooth hidden inside. Each tooth was then independently and blindly evaluated by the same three residents anatomically using a 4.5 x magnification. The results were averaged and compared to the radiographic results using a paired t-test. The paired t-test is the optimal statistical test when comparing two matched groups of quantitative data that is parametrically distributed as is the case in this study.

Results

Maxillary

In the 40 maxillary palatal roots examined (**Table 1**), the average discrepancy from radiographic gutta-percha terminus to the actual terminus was 0.6375 mm. The radiographic terminus was determined to average 0.2875 mm short of the radiographic apex. When these same teeth were examined clinically, the average actual gutta-percha terminus was 0.35 mm long of the apical foramen. The breakdown of each tooth's measurement discrepancy is shown in **Figure 1**. Using the paired t-test, these results were found to be quite significant.

Table 1.

The Difference Between the Radiographic and Anatomical Apices in the Maxillary Teeth

	N	Mean	Std. Dev.
Radiographic	40	-0.2875	0.4065
Actual	40	0.35	0.2931
Difference		-0.6375	0.412
P≤ 0.001			

Table 2.

The Difference Between the Radiographic and Anatomical Apices in the Mandibular Teeth

	N	Mean	Std. Dev.
Radiographic	50	-0.235	0.4022
Actual	50	0.41	0.4482
Difference		-0.645	0.4604
P ≤ 0.001			

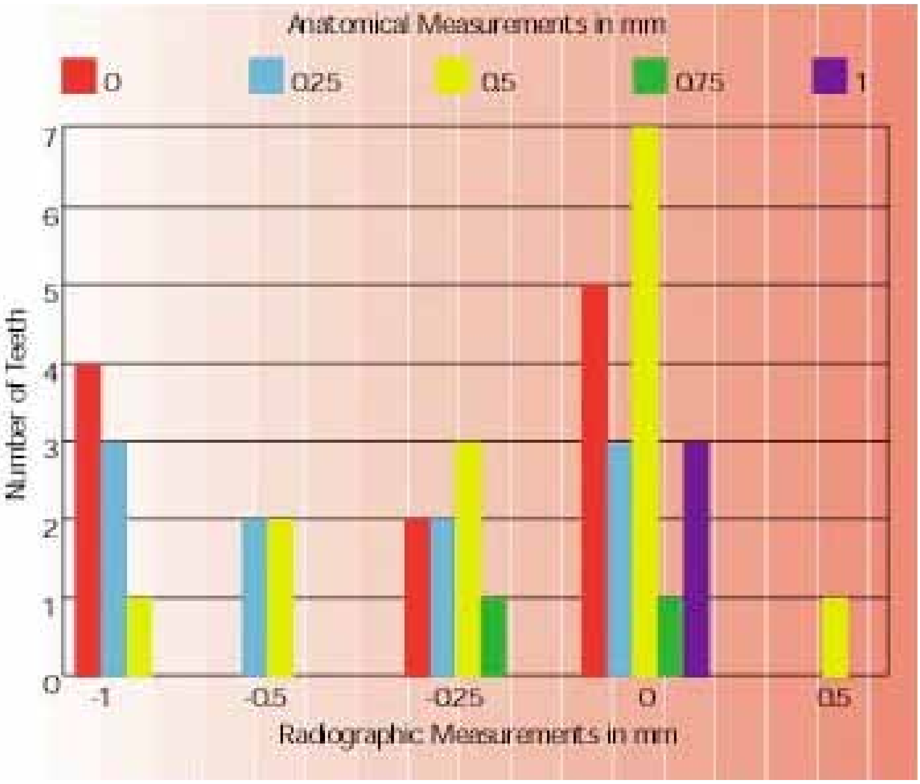

Figure 1. The breakdown of the discrepancy between each maxillary tooth's radiographic and actual gutta-percha terminus.

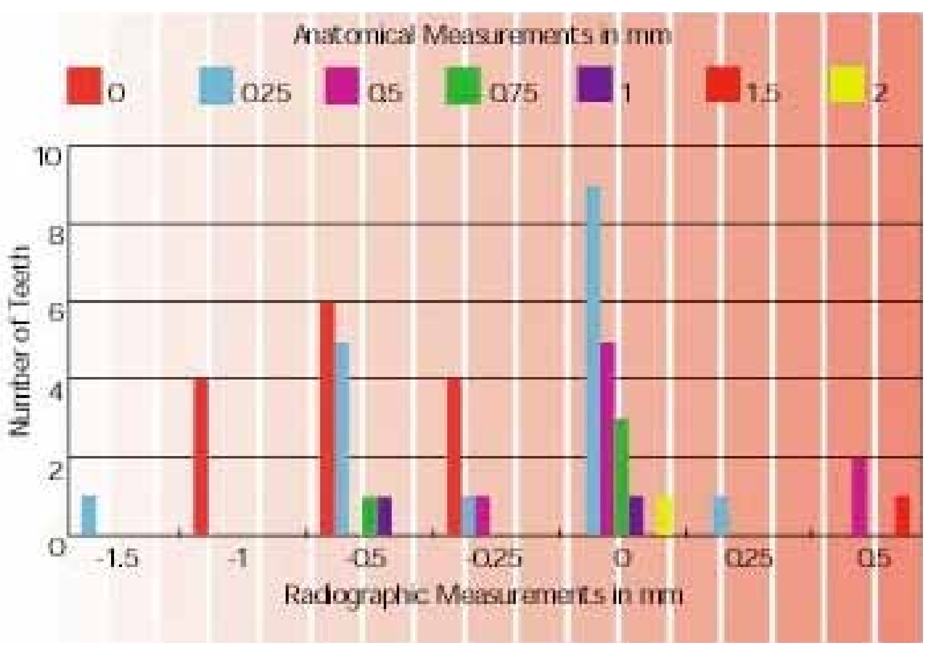

Figure 2. The breakdown of the discrepancy between each mandibular tooth's radiographic and actual gutta-percha terminus.

Mandibular

In the 50 mandibular distal roots examined (**Table 2**), the average discrepancy from the actual gutta-percha terminus to the radiographic terminus was 0.645 mm. The radiographic terminus was determined to average 0.235 mm short of the radiographic apex. When these same teeth were examined clinically, the actual terminus was 0.41 mm long of the apical foramen. The breakdown of each tooth's measurement discrepancy can be found in **Figure 2**. Using the paired t-test, these results were found to be quite significant

Conclusion

The intention of this study was to show that the practice of standardly finishing an obturation at the radiographic apex would result in many anatomical overfills. The literature supported these intentions. As the results in this study clearly demonstrate, the radiographic apex is frequently more apical than the actual foramen.

Root canal obturation should not be blindly placed at the radiographic apex. Rather, tactile sensation, operator experience, and aids such as apex locators should serve as a modifier for the radiograph during the course of root canal treatment.

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To request a printed copy of this article, please contact/ M. Sadegh Namazikhah, DMD, MSEd, USC School of Dentistry, 925 W. 34th St., Room 124C, Los Angeles, CA 90089-0641.

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Comparison Between Hand Stainless-Steel K File and Rotary NiTi 0.04 Taper

M. Sadegh Namazikhah, DMD, MSEd; Hussein R. Mokhlis, DDS, MSEd; Khalid Alasmakh, DDS, MSEd

ABSTRACT Straightening of curved canals is one of the most common procedural errors in endodontic instrumentation. It can lead to ledging, perforation, and stripping of the canal. The problem is commonly encountered when root canal preparation is performed in curved molars. The purpose of this study was to compare the results of root canal preparation by undergraduate dental students using traditional stainless-steel 0.02 taper K files to results obtained using rotary nickel-titanium 0.04 taper files. One hundred ninety six extracted teeth comprising maxillary and mandibular first molars were used. Preoperative and postoperative radiographs of each tooth were taken. Graduate endodontic residents evaluated the radiographs according to the evaluation criteria used by the endodontic department. The presence of errors – such as stripping, perforation, ledging, transportation, zipping, and instrument breakage – was recorded by examining the radiographs.

AUTHORS

M. Sadegh Namazikhah, DMD, MSEd, is a professor of clinical dentistry, acting chairman of the Endodontic Department, and director of the Advanced Endodontic Program at the University of Southern California School of Dentistry.

Hussein Mokhlis, DDS, MSed, is a second-year resident in the Graduate Endodontic Department at USC.

Khalid Alasmakh, DDS, MSEd, is a second-year resident in the Graduate Endodontic Department at USC.

The objective of root canal treatment is to completely seal a thoroughly cleaned and disinfected root canal system. A thorough debridement of the root canal system is an essential step toward this goal.[1] The process of debridement involves mechanical instrumentation and chemical irrigation. This combined technique will usually eliminate most of the bacterial contaminants of the canal, as well as the necrotic debris and contaminated dentin.[2]

However, cleaning and shaping the canal is not easy, especially in curved canals. The most difficult part of the canal to clean while maintaining its shape is the apical area. Instruments tend to straighten curved canals, resulting in elbow formation and transportation of the apex.[3] One of the most common procedural errors in the instrumentation of curved canals is the straightening of the root canal.[4] In addition, more-serious complications -- such as the development of ledges, apical zipping, instrument separation, canal transportation, and perforations -- have been reported in numerous publications.[5-7]

Taking preventive measures is the best means of avoiding the straightening of the canal and other procedural errors. An access cavity that will allow direct access to the apical part of the canals is essential.[8,9] Precurving the files and passively placing them in the canals is another important preventative measure.10 In an anticurvature instrumentation technique, orifice interferences are removed with an adequate flaring using rotary instruments.

ABLE 1

	Loss of Accurate Measurement			Ledging			Apical Perforation			Perforation Brokern			Instrument Transportation		
	Y	U	N	Y	U	N	Y	U	N	Y	U	N	Y	U	N
Lower Hand	23	2	24	6	3	40	3	1	45	1	1	47	14	4	31
Lower Rotary	19	1	29	4	5	40	4	0	45	1	2	46	8	10	31
Upper Hand	24	12	13	9	10	30	2	14	33	4	1	44	12	9	28
Upper Rotary	16	6	27	1	11	37	8	1	40	3	0	46	8	8	33

Table 2

	Sealer Overfill			Gutta-Percha Overfill			Gutta-Percha Underfil			Stripping of the Canal			Apical Zip		
	Y	U	N	Y	U	N	Y	U	N	Y	U	N	Y	U	N
Lower Hand	4	5	40	6	6	37	4	10	35	2	7	40	6	11	32
Lower Rotary	2	2	45	6	3	40	5	4	40	0	4	45	4	5	40
Upper Hand	9	5	35	7	5	37	6	6	37	1	2	46	5	4	40
Upper Rotary	3	4	42	6	5	38	5	8	36	1	8	40	6	9	34

Table 3

	Direct Entrance To the Canal				Flaring of Orifice				Under Condensed				Lack of Flare				Overall Evaluation			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Lower Hand	8	27	12	2	5	22	21	1	6	17	20	6	6	21	16	6	5	16	20	8
Lower Rotary	7	25	14	3	6	20	16	7	5	16	21	7	4	17	18	10	4	15	21	9
Upper Hand	2	17	27	3	0	16	25	8	0	9	29	11	0	9	26	14	0	4	32	13
Upper Rotary	5	14	25	5	3	16	23	7	4	10	18	7	3	15	20	11	3	12	24	10

A subsequent enlarging of the canal at the expense of the "safe" outer wall will help prevent such mishaps.[11] Despite these preventive measures, many problems still result from the use of files that are too rigid. Only with a great deal of practice and experience can a tactile "feel" be developed that overcomes the disadvantage of the rigidity of a file.[12]

Currently, hand instrumentation techniques using stainless steel K-files are used in the majority of dental schools. Due to the relative inexperience of the dental students performing these techniques, the incidence of straightening the canals and other procedural mishaps will increase. These mishaps led the authors to look for alternative treatment modalities that would reduce this phenomenon.

For the past 10 years, manufacturers have been examining various instrument designs to alleviate the problem of straightening curved canals. This resulted in improvements in the file tip design, changes in the cutting surface, and changes in the material of which the instruments are made. One of the most significant advances that might potentially alleviate the problem of straightening of curved canals is the nickel-titanium file.[13] NiTi is an alloy ideally suited for endodontic instruments. This alloy exhibits "superelasticity,"[14] a term used to describe the property of certain alloys that return to their original shape upon unloading from even a substantial deformation. Deformations involving as much as a 10 percent strain can be completely recovered in these materials, compared with a maximum of only 1 percent in conventional steel alloys.[15,16] NiTi instruments therefore allow operation with rotating movement beyond a curve in the canal, a feature rarely possible with conventional alloys.

Results of the comparison of NiTi files and stainless steel K-files in the instrumentation of acrylic blocks by dental students were promising for the NiTi files.[17] These findings encouraged the authors to continue evaluating this new alloy for endodontic use. If an emerging technology will improve the outcome of the work of even the most inexperienced operator, it should be of benefit in the hands of a more experienced operator.

The purpose of this study was to examine the capability of NiTi 0.04 taper rotary files to decrease the incidence of procedural errors (especially straightening of curved canals) in comparison to stainless-steel 0.02 taper K files in the hands of undergraduate dental students at the University of Southern California.

Materials and Methods

Sample Selection

One hundred ninety six extracted hydrated human molars that had been stored in a sterile saline and thymol solution were randomly selected to comprise equally of mandibular and maxillary first molars. They were assigned to 98 preclinical undergraduate dental students, and each student prepared one maxillary first molar and one mandibular first molar using a stainless-steel hand file in one molar and a rotary NiTi 0.04 taper in the other.

The students were divided into two groups according to their student number, forming an odd-student-number group and an even-student-number group.

The odd-numbered group was instructed to prepare the maxillary first molar using a hand stainless-steel K file. Concurrently, the even-numbered group was instructed to prepare the mandibular first molar using a rotary NiTi 0.04 taper (Tulsa Dental Products, Tulsa, OK). Subsequently, the odd-numbered group was instructed to prepare the mandibular first molar using rotary NiTi 0.04 taper at the same time the even group was instructed to prepare the maxillary first molar using hand stainless-steel K files. The time was constant in all the groups.

None of the students had prior experience in preparing molar teeth. Each student had preclinical experience in preparing six anterior teeth and four premolars.

Canal Preparation

A preoperative radiograph was taken. Each tooth was mounted in autopolymerizing acrylic resin. The cusp tips were flattened to simplify root canal length measurement, and a standard root canal access preparation was done using cylindrical diamond bur. A size # 10 stainless-steel K file was introduced into each canal; and the working length was established at 1 mm short of the radiographic apex using radiographs. A 5.25 percent NaOCl solution was used as an irrigant. The chambers and canals were flooded with irrigant during instrumentation, and 3.0 ml of irrigant was added after each file size.

The teeth treated with stainless steel hand files were prepared using the crown down coronal preflaring technique. The preflaring was accomplished with Gates-Glidden drills (4, 3, 2). Serial filing commenced with the initial file and progressed to the master file going to the full working length with each file. The teeth treated with NiTi rotary files were prepared using the crown down technique to 1 mm short of the working length as suggested by the manufacturer's representative. The remaining apical 1 mm was instrumented using NiTi hand files. The master files in both groups were the same. MB, ML and DB canals were enlarged to size #30. P and D canals were enlarged to size #40. The master file radiograph was then taken.

Obturation of all the groups was done by the lateral compaction technique using standardized ISO 0.02 taper gutta-percha cones and AH26 sealer. Mid-condensation and final radiographs were taken.

Evaluation of the Groups

The criteria used to evaluate the groups were as follows: loss of accurate measurement, direct entrance to the canal, flaring of the orifice, sealer or gutta-percha overfill, gutta-percha underfill, and undercondensation of gutta-percha.

The evaluation was done by comparing the preoperative and postoperative radiographs. The presence of ledging, perforation, transportation, stripping, zipping, and instrument breakage was recorded.

Ledging is defined as deviation of the root canal system from the original direction without communication with the periodontal ligament. Perforation is defined as artificial communication between the root canal system and

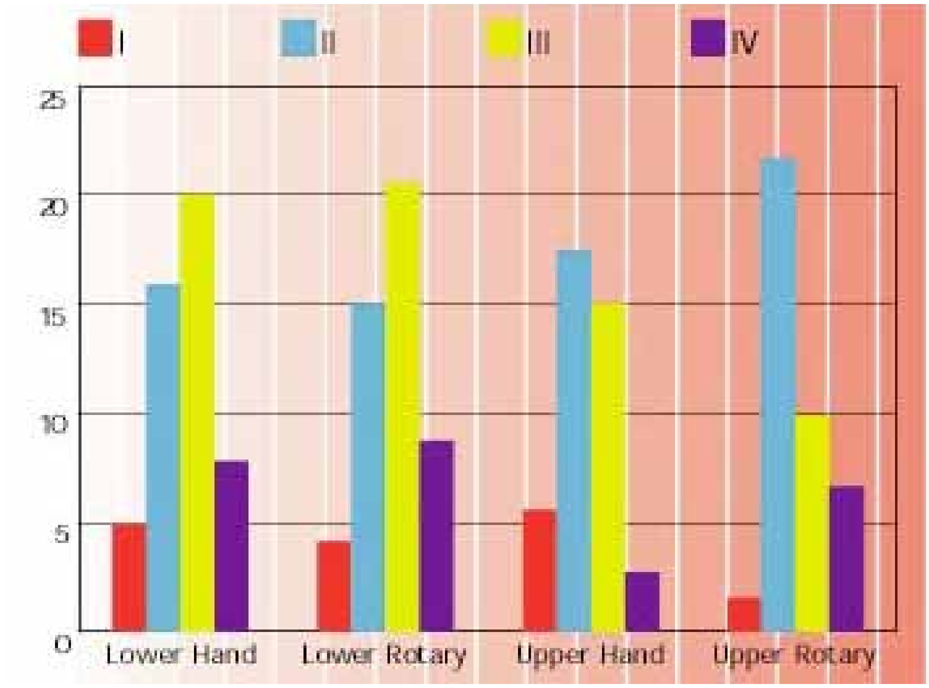

FIGURE 1. Compares the overall performance among the groups.

periodontal ligament.

The evaluation of the radiograph was done by four groups of two graduate endodontic residents. The mean scores were recorded. This evaluation was performed blindly: The residents were not aware of which technique was used in the teeth they were evaluating.

The chi-square statistical test was used to evaluate each variable tested in the study.

Results

Variables shown in Tables 1 and 2 are evaluated in the bases of yes (Y), uncertain (U), and no (N). Uncertain rank was given when there was a discrepancy between the evaluators. Variables in **Table 3** are evaluated in the on the basis of I, II, III, and IV, where I is the best and IV is the worst.

All variables tested showed no statistically significant difference except when comparing the upper rotary group with the upper hand group in both loss of accurate measurement and ledging. With both of these variables, the upper rotary group outperformed the upper hand group (**Table 1**).

In the overall evaluation of the cases, lower hand and lower rotary groups showed no statistically significant difference. The upper rotary group did however, outperform the upper hand group with a statistically significant difference ($p = 0.047$).

Discussion

Successful endodontic therapy is dependent on the practitioner's ability to safely and effectively debride and shape the root canal system. Many new instrument systems and instrumentation techniques have been introduced to the profession but have not been thoroughly evaluated. This study attempted to evaluate the results of the hand instrumentation technique using stainless steel 0.02 taper files and the rotary NiTi 0.04 taper in the hands of preclinical undergraduate dental students.

In this study, the authors selected the 0.04 taper NiTi rotary files and the 0.02 taper stainless steel hand files to compare the most used NiTi rotary system to its stain-less steel counterpart.

Unlike other studies where only a few, and usually gifted, students are selected to participate, in this study the entire class was allowed to participate regardless of individual performance records. In fact, the authors recognize that the gifted students performed at a higher level than the less talented students regardless of the technique used.

Time was not a factor in this study. Constant time was allowed for both techniques in the mandibular and maxillary molars.

In comparing the results of this study, the two techniques in question were not found to be statistically significant in decreasing the incidence of procedural errors by the inexperienced dental students.

Despite this statistical insignificance, the authors believe that the results obtained in a few of the variables need further discussion. For example, the rotary group outperformed the hand group in preventing both the loss of accurate measurement and ledging. This finding is due to two factors. First, the rigidity of the hand files creates more difficulty in maintaining the anatomy of the canal during filing procedures. For this reason, the incidence of ledging is much higher with the use of these files. Second, NiTi files are designed to drive debris up from the canal while stainless steel files tend to pack debris at the apical third causing loss of accurate measurement.

The incidence of apical perforation was more prevalent with rotary files. An inexperienced operator can easily apply an excessive apical force resulting in this type of perforation.

Summary

The skills necessary in the field of endodontics can best be learned with the use of hand filing techniques. Considering other factors, such as the considerable cost of NiTi rotary systems and the probability for NiTi files to separate, the authors recommend mastering hand filing techniques before moving on to rotary NiTi techniques.

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To request a printed copy of this issue, please contact/ M. Sadegh Namazikhah, DMD, MSEd, USC School of Dentistry, 925 W. 34th St., Room 124C, Los Angeles, CA 90089-0641.

Gutta-Percha: A Look at the Need for Sterilization

M. Sadegh Namazikhah, DMD, MSEd; David M. Sullivan, DMD; Gregory L. Trnavsky, DDS

ABSTRACT Many have argued that the prevention of contamination becomes a problem when gutta-percha cones are used to obturate the root canal space. This study evaluated the extent of contamination of commercially available gutta-percha cones taken directly from the manufacturer's box. Results show that if gutta-percha is not intentionally contaminated, there is no need for chemical decontamination before obturation.

AUTHORS

M. Sadegh Namazikhah DMD, MSEd, is a professor of clinical dentistry, acting chairman of the Endodontic Department, and director of the Advanced Endodontic Program at the University of Southern California School of Dentistry

David M. Sullivan, DMD, is a first-year resident in the Graduate Endodontic Department at the USC School of Dentistry.

Gregory L. Trnavsky, DDS, is a first-year resident in the Graduate Endodontic Department at USC.

One of the key goals of successful endodontic therapy is complete obturation of the root canal system. This success is directly related to the thorough elimination of microorganisms during cleaning and shaping. Use of improperly sterilized endodontic instruments increases the potential for contamination. This is easily avoided through autoclaving of the endodontic instruments, having a clean set-up, and using a rubber dam to isolate the tooth from the oral microflora.

Many have argued that the prevention of contamination becomes a problem when gutta-percha cones are used to obturate the root canal space.[1] However, since gutta-percha does not readily lend itself to sterilization by heat, other methods have been studied. This argument triggered a series of studies testing various chemical agents in the decontamination of gutta-percha cones. Sodium hypochlorite[2-5] and gluteraldehyde[6] were the two chemicals that gained the most support from researchers in the decontamination of gutta-percha cones. Other chemicals used to decontaminate gutta-percha were chlorhexidine,[3] ethyl alchohol,[3] isopropyl alchohol,[3] hydrogen peroxide,[4] Zephirin,[7] Zephirin chloride,[8-10] untinted tincture of Metaphen,[11] thimerosal,[12] povidine-iodine,[1] formaldehyde gas,[13] and paraformaldehyde.[3,14] In many of these studies, researchers intentionally contaminated the gutta-percha with various strains of bacteria prior to testing the efficacy of these chemical decontaminants.

FIGURE 1. A manufacturer's box of gutta-percha cones.

FIGURE 2. Cones from Group 1a are rolled across a blood agar plate.

FIGURE 3. Cones from Group 1c are placed in an agar plate without rolling.

FIGURE 4. A plastic organizer for gutta-percha cones.

It is interesting to note that there are only two studies published that focused on testing gutta-percha, taken directly from the manufacturer's packaging, for contamination. In 1971, Montgomery published his findings in which gutta-percha was taken out of the factory packaging and placed directly into culture media. In this study, 8 percent of the commercially manufactured cones tested showed growth. He concluded that the organisms identified were pathogens, indicating the necessity of decontaminating gutta-percha cones prior to placing them in root canals. Doolittle and colleagues, in 1975, took 24 gutta-percha points directly from the manufacturer's box and placed them in a culture broth. None of the gutta-percha cones tested were positive for bacterial growth. It was on the basis of Montgomery's article alone that the subsequent studies were done using chemical agents to "rapidly decontaminate" gutta-percha cones.

In 1982, Moorer and Genet did a study testing the antibacterial property of gutta-percha cones and found zinc oxide, which is the major component of gutta-percha, to be responsible for some antibacterial properties of the cones. Martin, in 1999, published an article promoting a medicated gutta-percha cone. This formulation (containing iodoform) has been developed to act as an inhibitor of microbial growth within the root canal.

In addition to the gutta-percha cones, root canal sealers are routinely used to help provide a hermetic seal in the obturation process. To achieve this effective seal and subsequent healing of an endodontic lesion, a root canal sealer should possesses certain characteristics. Grossman[18] has identified several characteristics considered to be ideal for a root canal sealer. One of these characteristics is that it must have bactericidal and/or bacteriostatic activity. Studies have been done evaluating the antimicrobial activity of various endodontic sealers. One study found that many sealers inhibited the growth of certain known dental pathogens.[19] Al-Katib and colleagues, in 1990, tested the ability of sealers to inhibit the growth of Streptococcus mutans (a gram-positive microaerophile), Staphylococcus aureus (a gram-positive facultative anaerobe), and Bacteroides endodontalis (a gram-negative obligate anaerobe).[20] B. endodontalis, a known endodontic pathogen, has been found in necrotic pulps and radiolucent periapical lesions.[21,22] In the study done by Al-Katib and colleagues, of all the sealers tested, AH26 was most effective against B. endodontalis.

The purpose of this study was to:

- Evaluate the extent of contamination of commercially available gutta-percha cones taken directly from the manufacturer's box.
- Assuming contamination was present on the gutta-percha cones, the antimicrobial effect of 5.25 percent sodium hypochlorite was evaluated.
- Assuming contamination was present on the gutta-percha cones, the antimicrobial effect of a root canal sealer was evaluated.

Materials and Methods

This experiment was conducted in a decontaminated clinical environment to duplicate as close as possible an actual clinical setting. All testing procedures were performed by a single operator in OSHA-approved clinical attire. A total of 64 ISO size #40 gutta-percha cones were used. The 64 cones were separated into two groups.

Group 1

The first group consisted of 32 gutta-percha cones taken directly from a sealed manufacturer's box (**FIGURE 1**). This group was subdivided into four subgroups. Group

Table 1.			
Three-Day Results			
Group	Colony Counts	Bacteria	Comment
1A	Two cones-Hemolysis zone	*Bacillus species*	Gram-negative rod Nonpathogenic
1B	No growth		
1C	No growth		
1D	No growth		
2A	Two cones-Hemolysis zone	*Bacillus species*	Gram-negative rod Nonpathogenic
2B	No growth		
2C	No growth		
2D	No growth		
3	2, 13, 50, 44		

Table 2.			
Seven-Day Results			
Group	Colony Counts	Bacteria	Comment
1A	Two cones-Hemolysis zone	*Bacillus species*	Gram-negative rod Nonpathogenic
1B	No growth		
1C	No growth		
1D	No growth		
2A	Two cones- Hemolysis zone	*Bacillus species*	Gram-negative rod Nonpathogenic
2B	No growth		
2C	No growth		
2D	No growth		
3	2, 13, 50, 44		External contami-nants

Table 3.			
Fourteen-Day Results			
Group	Colony Counts	Bacteria	Comment
1A		*Bacillus species*	Gram-negative rod Nonpathogenic
1B	No growth		
1C	No growth		
1D	No growth		
2A	Two cones-Hemolysis zone	*Bacillus species*	Gram-negative road Nonpathogenic
2B	No growth		
2C	No growth		
2D	No growth		
3	2, 13, 50, 44		

1a consisted of eight gutta-percha cones removed from the box and placed directly onto a blood agar plate (**Figure 2**). The cones were then carefully rolled across the agar surface. Group 1b contained eight gutta-percha cones taken directly from the box and immersed in undiluted 5.25 percent sodium hypochlorite for one minute. (This strength of sodium hypochlorite was used based on the findings of Senia and colleagues in 1975.) The cones were allowed to air dry for five minutes on a sterile surgical drape and placed on the agar plate as mentioned in group 1a. Group 1c consisted of eight gutta-percha cones evenly coated with AH-26 cement that was mixed on a sterile glass slab according to the manufacturer's directions. The cones were placed on the blood agar immediately after being evenly coated with cement but were not rolled as in groups 1a and 1b (**Figure 3**). Group 1d also consisted of eight gutta-percha cones that were immersed in 5.25 percent undiluted sodium hypochlorite as in group 1b and were then coated with AH-26 cement and place on the blood agar as in group 1c.

Group 2

A common practice for many endodontists is to store their gutta-percha cones in a plastic organizer (**Figure 4**). As part of this research, the authors were interested in evaluating the contamination of gutta-percha stored in these organizers.

Group 2 consisted of 32 gutta-percha cones taken from one of these organizers. As in group 1, group 2 was divided into four subgroups (a, b, c, d); and the same testing procedures were performed.

A positive control group was also incorporated into this study. Four gutta-percha cones taken from the manufacturer's box were intentionally contaminated by rolling in the operators degloved hand for one minute. These four cones were then placed on the agar plate and rolled as in groups 1a and 2a.

All agar plates were incubated at 37 degrees C and examined for bacterial growth at three, seven and 14 days.

Summary of Groups

Group 1 (32 gutta-percha cones)

- Group 1a – eight cones from manufacturer's box.
- Group 1b – eight cones from manufacturer's box with NaOCl.
- Group 1c – eight cones from manufacturer's box with AH-26 cement.
- Group 1d – eight cones from manufacturer's box with NaOCl and AH-26 cement.

Group 2 (32 gutta-percha cones)

- Group 2a – eight cones from endodontist's box.
- Group 2b – eight cones from endodontist's box with NaOCl.
- Group 2c – eight cones from endodontist's box with AH-26 cement.
- Group 2d – eight cones from endodontist's box with NaOCl and AH-26 cement.

Group 3 (four gutta-percha cones) positive control

Four intentionally contaminated cones.

Results

Tables 1, 2 and 3 show the results of bacterial growth of the same gutta-percha cones at three, seven, and 14 days.

The results of the cultures are listed in Tables 1, 2 and 3. The results in **Table 1** show that after three days of incubation, two cones in Group 1a, showed the presence of bacteria. After one week of incubation, depicted in **Table 2**, two additional cones, this time in Group 2a, showed the presence of the same bacterial species. The 14-day group, shown in **table 3**, had no changes from **Table 2**. It was explained to the authors by the microbiologist performing the cultures that the bacteria were of the Bacillus species. This particular organism is a nonpathogenic, gram-negative rod.

The positive control group, Group 3, had colony counts that ranged from two to 50. Aside from the positive control group, no other bacteria were detected in the culturing of the agar plates.

Discussion

As mentioned earlier, several studies have been done on the chemical decontamination of gutta-percha.[2-14] Most of these studies used gutta-percha cones that were intentionally contaminated with various strains of bacteria prior to testing the efficacy of the chemical decontaminating agent. These studies were done based on the findings of Montgomery, in 1971, who found that 8 percent of the cones he tested directly from the manufacturer's box were positive for bacterial growth. The purpose of Group 1a was to test gutta-percha from the sealed manufacturer's box, essentially duplicating that aspect of Montgomery's study in 1971. The results showed that 25 percent, or two out of the eight cones tested in Group 1a were positive for the presence of bacteria. The zone of hemolysis on the blood agar surface indicated the presence of the Bacillus species of bacteria, which is a nonpathogenic, gram-negative rod. In Group 1b no bacterial growth was present. In this group, the gutta-percha was submerged in sodium hypochlorite for one minute and allowed to air dry on a sterile surgical drape before being placed on the agar plate. Advocates of chemical disinfectants would support that the absence of bacteria in this group is due to the antibacterial effects of the sodium hypochlorite.Group 1c also showed no bacterial growth. In this group, the gutta-percha was coated with the sealer AH-26 prior to being placed on the agar plate. As reported in the studies of Barkhordar, 1989, and Al-Khatib and colleagues, 1990, one could argue that this is due to the antimicrobial properties of AH-26.Group 1d contained gutta-percha, which was submerged in sodium hypochlorite for one minute as in group 1b and coated with AH-26 as in group 1c. As one might expect from groups 1b and 1c, no bacterial growth was present.In Group 2, gutta-percha was tested from the plastic organizing boxes. The results from Group 2 were identical to group 1. Given these results, these boxes may be a safe alternative for the storage of gutta-percha. In addition, these gutta-percha points may not require chemical decontamination with sodium hypochlorite if they are to be coated with AH-26 prior to placement in the canal. Doolittle, in 1975, found no gutta-percha cones positive for contamination when taken directly from the manufacturer's box. Montgomery, in 1971, found eight percent of the gutta-percha tested was contaminated. In addition, Al-Khatib and colleagues stated the antimicrobial effects of AH-26 in 1990. Given these results and the results from the current study, the chemical decontamination of gutta-percha points with sodium hypochlorite may not be a necessary if AH-26 root canal sealer is used. Conclusion

It can be concluded from this study that:

- Of the gutta-percha tested, two out of eight cones were positive for the presence of bacteria.
- Gutta-percha taken directly from the manufacturer's box and immersed in sodium hypochlorite for one minute showed no bacterial growth when placed on an agar plate.
- Gutta-percha taken directly from the manufacturer's box and coated with

AH-26 showed no bacterial growth when placed on an agar plate.

It was the authors' purpose to address the issue of chemical decontamination of gutta- percha. According to the results, if gutta-percha is not intentionally contaminated, there is no need for chemical decontamination before obturation. Furthermore, if AH-26 root canal sealer is to be used, there is more assurance of the decontamination of the gutta-percha.

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Dye Leakage Study: Comparing Conventional and New Techniques

Sadegh Namazikhah, DMD, MSEd; Ramiar Shirani, DDS; Amir Mohseni, DDS; and Fariborz Farsio, DMD

ABSTRACT The purpose of this study was to compare the degree of dye penetration of Thermofil and Simplifill to standard lateral condensation using AH26 plus. Forty-five human maxillary incisors were instrumented and obturated with three different methods: Rotary Profile with the Thermofil method and AH-26 Plus sealer, Rotary Lightspeed with the Simplifill method and AH-26 Plus sealer, and hand file with lateral condensation and AH-26 Plus. An additional 45 teeth were used as positive controls in three separate but corresponding groups, and another 15 were in a negative control group. Apical leakage was measured and evaluated on both the internal canal surfaces and the obturation material itself. The results showed that there was a significant difference between the control and obturated groups but no significant difference between any obturation groups.

AUTHORS

M. Sadegh Namazikhah DMD, MSEd, is a professor of clinical dentistry, acting chairman of the Endodontic Department, and director of the Advanced Endodontic Program at the University of Southern California School of Dentistry.

Ramiar Shirani, DDS, is a postgraduate endodontic resident at the USC School of Dentistry.

Amir Mohseni, DDS, is a postgraduate endodontic resident at the USC School of Dentistry.

Fariborz Farsio, DMD, is in the International Student Program at USC School of Dentistry.

Root canal obturation consists of placing an inert filling material in the space previously occupied by pulp tissue. To achieve successful endodontic therapy, it is important to obturate the root canal system completely.

Gutta-percha is used with various techniques for obturation of the root canal system. Chemically pure gutta-percha exists in two crystalline forms: alpha and beta. The forms are interchangeable depending on the temperature of the material. When heated, the initial beta form changes to the alpha form. When cooled, it can change back into the beta form.1 The alpha form has adhesives and a low viscosity. This type is found in Thermofil. The beta form has no adhesion characteristics but has a higher viscosity. This type is typically found in standard gutta-percha points.

Throughout the years, a variety of techniques using gutta-percha have been developed for root canal fillings. These techniques include lateral condensation, Kloroperka, Chloropercha, warm vertical condensation, injectable thermoplasticized, Ultrafill, and Thermofil. Investigators have evaluated the apical seals obtained by these various gutta-percha filling techniques.

Lateral condensation remains the most widely accepted and used obturation technique.[2] As a result, all other techniques are compared to it to evaluate success.

In 1978, Johnson[3] demonstrated a simple method of carrying thermoplasticized gutta-percha to the extent of a prepared canal. A flexible metal carrier the same size as the final apical instrument is coated with alpha form gutta-percha. The carrier is used to transport the gutta-percha to the working length, then to compact it using a single insertion motion. This method of obturation was marketed under the name of Thermofil Endodontic Obturation System (Tulsa/Dentsply Dental Products). The newer system uses a plastic rather than metal carrier.

In 1999, Lightspeed Technologies introduced the Simplifill Obturation System. It utilizes a metal carrier, which has an apical gutta-percha plug that is 3 to 4 mm at the end. The carrier is removed during the obturation process. This technique is used in conjunction with the Lightspeed Rotary Nickel Titanium Reamer.[4] This is the most recently introduced obturation product on the market.

Studies have shown that Thermofil has shown less apical dye penetration than the single-cone obturation and laterally condensed gutta-percha.[5] Other studies have shown significantly less leakage with lateral condensation than Thermofil.[6] In a more recent study, there was no significant difference in the leakage between lateral condensation and the sectional Simplifill method[7] (**Figure 1**).

The sealer recommended by both manufacturers is the new AH-26 Plus. This new sealer does not form paraformaldehyde when mixed, as did the original AH-26 sealer. Another modification is the increased amount of barium sulfate introduced into the sealer to give it a more radiopaque appearance.[8,9]

A review of the literature failed to reveal any studies comparing lateral condensation, Thermofil, and Simplifill obturation techniques directly.

The purpose of this study was to determine if Thermofil or Simplifill, and the techniques recommended by each manufacturer to prepare the canals, result in significantly less leakage penetration than the standard of hand filing and lateral condensation using AH-26 Plus. To do this, the Thermofil and Simplifill methods were used in accordance with manufacturer instructions in two groups containing 15 teeth each. The third comparison group, also with 15 teeth, used the traditional lateral condensation. Four additional groups, each also containing 15 teeth, were used for three corresponding positive controls and one negative control.

Figure 1. From left to right, Light speed rotary file, Simplifill, Tulsa rotary file, Thermofil.

Methods and Materials

One hundred and five extracted straight central incisors were selected and distributed randomly in seven equal groups denoted by numbers 1 through 7. The selected teeth were radiographed from buccolingual and mesiodistal views. The radiographs were used to determine the canal shape and patency. Teeth that had any curvature or calcification were eliminated from the study and replaced.

Group 1

This group was prepared using the Thermofil system and Tulsa rotary instrumentation files (.04 taper ISO series). Lengths were determined by introducing a #10 K-type stainless steel file to the apex of the tooth. The file was observed visually as it exited the canal, and a measurement was recorded at that time. Then 1 mm was subtracted from that measurement. This was the working length measurement.

The canals were serially filed to size 15 with stainless steel K-type files to the working length. Then, in a crown-down fashion as described by the manufacturer, the Orifice Shaper instruments were introduced into the canal to flare the coronal area of the tooth. The crown down technique was continued with the ISO .04 series of instruments to the apex. The NiTi hand files were then used to ream the apex to adequate size as determined by the operator. The range of apical sizes was from 50 to 60. After preparation was finished, the taper and size of the canal was verified using the plastic verifying tools as described by the manufacturer. The canals were irrigated and dried with paper points to allow for obturation.

At this point, the corresponding Thermofil was heated in the oven provided by the manufacturer. AH-26 Plus, as recommended by the manufacturer, was applied to the walls of the preparation using the master file. After adequate heating, as indicated by the automatic oven, the carrier was delivered into the orifice of the canal to the working length. The handle was cut using a high-speed round bur and the remainder reduced to 2 mm below the orifice to allow space for temporary material. Cavit was placed into the orifice to ensure a good seal.

Group 2

This group consisted of 15 teeth used as positive controls for Group 1. This group was prepared in the same manner as Group 1 but was not filled with any obturation material.

Each group had its own positive control because the canal preparation techniques for each obturation material were unique. Therefore, a group prepared with the Lightspeed technique had to be compared to a positive control prepared in a similar fashion. A group prepared with the Tulsa rotaries that was to receive the Thermofil obturators could not be compared with a positive control group that was not prepared in a similar fashion, i.e., a hand file group.

Group 3

This group was prepared with the Lightspeed system and filled with the Simplifill obturation technique. The teeth were accessed and working lengths determined in the same manner as for Group 1. The preparation was performed as demonstrated in the video directions

Figure 2. Example of the overextrusion that occurred in some samples from the apex of the tooth using the Thermofil obturation system.

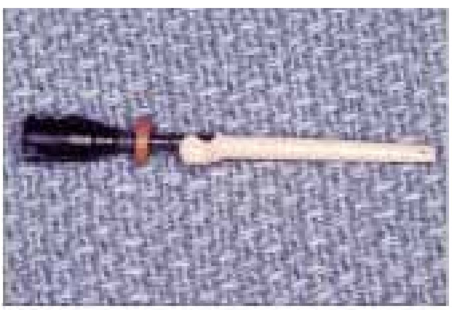


Figure 3. Example of a new Thermofil carrier size 40 straight from the manufacturer. Note that the plastic carrier is showing through the gutta-percha even in unused samples.

Figure 4. Example of a sectioned sample that had gutta-percha stripping at the apical portion of the penetration. This may have clinical implications.

provided by the manufacturer. The technique is as follows. After the working lengths were determined, the canals were serially enlarged with a stainless-steel file to a size 15. The coronal one-third was preflared using Gates-Glidden burs. Nos. 3, 2, and 1 were introduced sequentially in a crown-down fashion until one-third of the measurement had been reached. Then the smallest Lightspeed to bind was introduced into the canal by hand. This instrument was inserted into the battery-operated handpiece and turned on to rotate at the maximum speed of 2,000 rpm as recommended by the manufacturer. With adequate lubrication (NaOCl), the instruments were inserted into the canal and forwarded to the working length. Subsequent larger instruments (the next instrument in the series) were introduced into the canal to the working length and continued until 12 pecks of motion was reached as described by the manufacturer. The instrument used to acquire the 12 pecks is known as the master apical rotary. This was the last file to be used in the canal, and an X-ray was taken to ensure adequate maintenance of the working length. The apical preparation size ranged from 40 to 80. The average size was 55. Then the next larger rotary was introduced into the canal to 5 mm short of the working length. The preparation was completed at this point, and the canal was ready to be filled with the Simplifill system. AH-26 Plus cement sealer was mixed and used as recommended by the manufacturer. The Simplifill size was the same size as the master apical rotary used. The Simplifill was coated with sealer and introduced to the working length. The handle was then separated from the gutta-percha plug by a counter-clockwise twisting action of the handle. The rest of the canal was filled with sealer using a centrix syringe tip to deliver it into the canal until reaching 2 mm short of the orifice, again allowing space for future placement of the temporary material. Subsequently, the largest size gutta-percha point that would reach the Simplifill plug was placed into the canal. Accessory cones were placed as space provided but without any spreading, as directed by manufacturer. Cavit was placed into the orifice for sealing.

Group 4

This group consisted of 15 teeth that were used as positive controls for Group 3. They were prepared in a similar manner as in Group 3 except that they were not obturated.

Group 5

This group was the lateral condensation group.

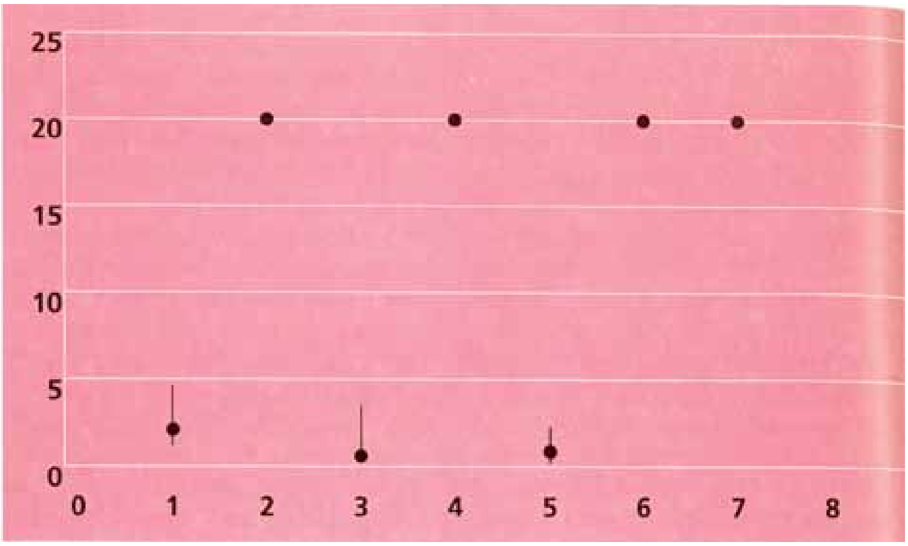
The working length was determined as in previous groups. Then preparation began with K-type files introduced to the working length and filed up to size 25. The preflaring was accomplished as in Group 3. The apices were serially prepared up to a size 50, and the apical portions were merged with the middle portion by hand flaring with the last file. Throughout the procedure, NaOCl was used for irrigation. The canals were dried with paper points, and a final radiograph was taken with the final file to length to determine the position of the apical preparation. A D11T spreader was introduced to length to determine the adequacy of flare. The spreader passed to length without any resistance.

Traditional lateral condensation was done by placing a master cone to length using AH-26 Plus for sealer. At least two accessory cones were placed to within 1 mm of length. The rest was filled with cones as the preparation permitted. Radiographs were taken and evaluated by two independent endodontists for adequate condensation. Both agreed as to the adequacy. If not, more cones were placed until agreement was reached as to the radiodensity of the fill. The excess was burned off to 2 mm below the orifice, and cavit was placed in the orifice for seal.

Group 6

This group consisted of 15 teeth used as positive controls for Group 5. The teeth were prepared in a similar manner as Group 5 except that they were not obturated using lateral condensation.

Table 1. Mean amount of leakage in millimeters with standard deviations including error bars.

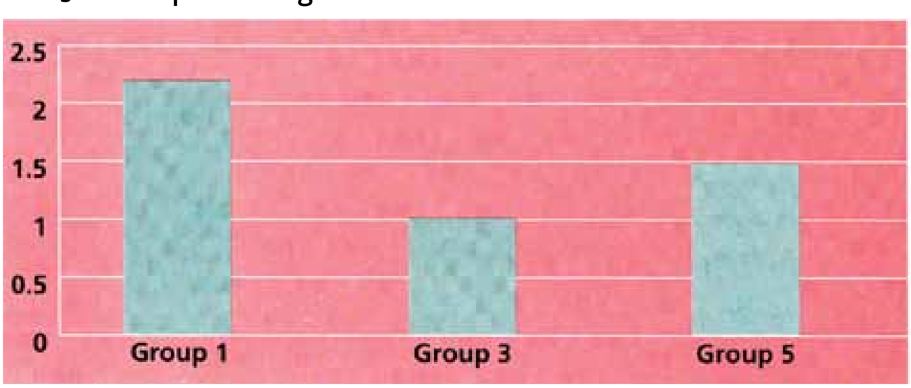


Group 1 – Thermofil; Group 2 – Positive control prepared with Tulsa rotary files; Group 3 – Simplifill; Group 4 – Positive controls prepared with Lightspeed files; Group 5 – Lateral compaction; Group 6 – Positive controls prepared with hand files; Group 7 – negative controls with no preparation.

Table 2. Results from dye study using ANOVA Statistical Analysis.

Group	Technique	Mean mm Leakage	SD	SEM
1.	Thermofil	2.208	1.249	0.51
2.	Thermofil positive control	20	0	0
3.	Simplifill	1.042	1.478	0.6035
4.	Simplifill positive control	20	0	0
5.	Lateral compaction	1.5	0.8944	0.3651
6.	Lateral compaction positive control	20	0	0
7.	Negative control	20	0	0

Table 3. Mean Apical leakage in millimeters.



Group 1 – Thermofil; Group 3 – Simplifill; Group 5 – Lateral compaction.

Group 7

This group was the negative control group or no-treatment group. No instrumentation was performed in this group.

Following obturation, the root surfaces of all the samples were coated with two layers of clear nail polish resin up until the apical 2 mm. The apical 2 mm were free of any resin materials. There was an increase in lateral canal presence or delta formation in the apical area, but randomization of the sample distribution should have accounted for this variability. Other studies also utilized this technique for elimination of lateral canal leakage anywhere other than the apical 2 mm area.[10] The teeth were then glued from the incisal edges to a tongue depressor perpendicularly and immersed into a plastic container of India ink, which engulfed two-thirds of the root. The container was covered and allowed to sit for seven days from the time of submersion.[11,12]

Results

The teeth were sectioned vertically along their long accesses. To ensure that the sectioning process did not damage the inside of the canal, the operator vertically cut with a diamond disc along the root short of reaching the gutta-percha, thereby creating a stress canal.10 A chisel was used to wedge and split the teeth. The teeth were then randomly distributed in the group for evaluation. Two observers who were unaware of the research purpose or protocols were asked to use a stereomicroscope to identify any blue dye that may have penetrated into the root canal, including the walls of the preparation or the middle of the filling, which may also leak. The evaluators measured dye leakage with a millimeter-scaled ruler under a 5x stereomicroscope (Global Surgical Corp., St. Louis) from the apical constriction to the longest point of dye penetration along the canal wall or gutta-percha itself. A maximum of 20 mm was recorded due to the variation in lengths of each sample tooth.

Statistics

The analysis of variance was used to compare leakage among the seven groups. Upon finding significance, Bonferroni-adjusted multiple pairwise Mann-Whitney tests were used to determine which treatment groups differed from one another. A pairwise test was considered statistically significant if $p<0.005$.

The ANOVA results are shown in **Figure 2** and **Table 1**. There was statistically significant difference among the seven groups ($p<0.001$). Pairwise multiple comparisons showed that the Thermofil (Group 1), Simplifill (Group 3), and lateral compaction (Group 5) techniques differed from the instrumented-but-unfilled groups (Groups 2, 4, and 6) and the no-treatment group (Group 7) but did not differ statistically from one another (**Table 3**).

Discussion

A literature review of 15 studies by Beck and Donnelly found no significant difference between the apical leakage of Thermofil and lateral condensation.[13] This is consistent with the present study. The current study is also consistent with one done by Santos and Walker that compared apical leakage allowed by lateral condensation to that allowed by the Simplifill technique.[7] The results were similar, although Santos and Walker used different kinds of sealers. The purpose of this study was to evaluate and compare all three techniques since no such study has yet been published to the best knowledge of the authors. The authors also noted that most of the studies reviewed failed to utilize the sealer recommended by the manufacturer: AH-26 Plus. In the current study, the sealers were consistent with manufacturer recommendations and consistent among sample groups.

The current study used seven groups. Group 1 was the Thermofil group and was prepared as recommended by the manufacturer by using the Tulsa/Dentsply rotary NiTi files. Group 2 was its positive control and was separate and distinct due to its preparation requirements. Group 3 was the Simplifill group and was prepared using the Lightspeed rotary NiTi files. Group 4 was its positive control, which had a separate and distinct preparation technique. Group 5 was the hand file and lateral condensation group. Group 6 was its distinct positive control. Group 7 was the no-treatment group. Three distinct positive controls were used to ensure that the statistical analysis would be accurate due to the separate and distinct preparation techniques required for each filling group.

In this study, both the no-treatment control group (Group 7) and the instrumented-but-unfilled groups (Groups 2, 4, and 6) had leakage throughout the canal. Since each tooth was of differing lengths, a maximum of 20 mm was recorded to simplify and standardize analysis calculations. The untreated control group was coated with resin polish in a similar fashion as the other groups, leaving the apical 2.0 mm free of any resin material. It is believed that the dye enters the apical foramen through capillary action.

Although there was no significant difference in the dye penetration between the test groups, there were some interesting observations that should be mentioned. During the obturation using Thermofil, the operator routinely noticed that the thermoplasticized gutta-percha or sealer would be pushed through the apex regardless of the final apical size. In some cases, there seemed to be a large amount of material extruded from the end of the root (**Figure 4**). This may have severe clinical implications because this technique may, in fact, cause a high number of overfills.

Also, when the authors examined the split sections after evaluation, the plastic carrier often seemed stripped of the gutta-percha that should have surrounded it, and only sealer remained surrounding the core (**Figures 5 and 6**).

As in the Thermofil cases, the operator found that in the Simplifill cases a high number of samples had overextrusion of the sealer from the apex regardless of the master apical rotary final size. The apical plug itself remained in the canal. This overextrusion may be attributed to the fact that the apical plug corresponds very closely with final apical preparation size and that the snug fit of the plug acts as a plunger, hydraulically forcing the sealer out the apex. It was also noted that the area in the canal above the apical plug had a significant amount of voids. This may be attributed to the backfill technique, which allows passive placement of accessories and does not suggest spreading of the gutta-percha in the coronal area.

In both these cases, the extrusion of the sealer would manifest as a sealer "puff" or "umbrella." This again may have clinical implications that need to be examined, but it should be noted that the release of paraformaldehyde observed from the conventional AH-26 is not seen with the new AH-26 Plus. If this is indeed the case, then the overextrusion may not be as relevant. Whether or not this new formulation has less of an irritating effect needs to be evaluated in future studies. The overextrusion of the material may also have an effect on the leakage. Theoretically, in the Thermofil technique, this overfill of "puff" may compensate for any shrinkage that may occur due to the cooling of the gutta-percha. The cooling may in fact pull some of the sealer or gutta-percha back into the canal, thereby giving a false sense of seal at the apex. Over time, when the sealer or gutta-percha gets resorbed by the body, leakage may continue where the shrinkage has occurred.

Conclusion

In general, the authors believe that the standard lateral technique gave the most consistent results; and it had minimal, if any, overfills that may irritate the periapical tissues. No significant difference was found in leakage amounts. Both new techniques and sealer show promise, but further refinement of each technique and further investigation in vivo must be done to evaluate compatibility in the oral cavity.

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To request a printed copy of this article, please contact/ M. Sadegh Namazikhah, DMD, MSEd, USC School of Dentistry, 925 W. 34th St., Room 124C, Los Angeles, CA 90089-0641.

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Waiting...

Robert E. Horseman, DDS

One hour. One hour and a quarter. Seventy-five minutes I've been squirming in my doctor's reception room – first one cheek, then the other. The eclectic reading material consists of Family Circle, Redbook and a 3-week-old copy of Time and was exhausted in the first half hour. I now know more than I ever wanted to about estrogen replacement therapy, and I could make a cherry pie, Billy Boy, if I had to.

What is it with these guys? He's not even a surgeon – how many emergencies can an internist have? Ten o'clock, the receptionist said when I called for the appointment. Apparently this is doctor time and has no counterpart in the real world except perhaps wife time (which has to do with shopping or getting ready to leave the house).

I believe there is a course in medical school where future physicians are taught how to use time to their advantage. In a single semester, they could discover that the worth of the patient's time is inconsequential; whereas, the doctor's time is pure gold. This could be incorporated in the course content of "The Waiting Room – The Power Begins Here."

In what seems like the amount of time it took me to finish the seventh grade, but is 10 minutes in doctor time (1 1/2 hours real time), a squarish woman sporting some Nautilus-derived figure enhancements, opens the door to the inner sanctum. "Mr. Horseman, please come this way." In some hipper offices I've bivouacked in, a comely miss barely out of puberty addresses me as Robert and seems pleased when I blurt, "Call me Bob, Janey," indicating that the three-generation difference in our ages will be no barrier to our relationship.

Miss Muscle Beach leads me right onto a scale, fiddles with the weights for a while, and announces my gross tonnage to the world at large, ignoring my protests that my wingtips weigh five pounds apiece, and my loose change, pocket knife and nail clippers would account for another couple of pounds. "Sure, Mr. Horseman," she says crisply, writing down what the scale wrongly estimated, then ushers me into another room, known in medical parlance as a "cubicle."

Only the medical profession has a series of waiting rooms, each one smaller and more Spartanly appointed than its predecessor. It would be considered appropriate for solitary confinement in any federal pen, if the ambience were a bit more cheerful. There are no windows, so after the maze of hallways, it's difficult to place myself spatially.

This is the Motel 6 of treatment rooms. It features a little five-caster stool for the doctor and a square backless bench that I assume is for me to squat on while scanning the bare walls, furtively looking for an escape route and calculating how many years I have left of my sentence. There's a table – the kind that physicians acquire when they first go into practice – covered in brown vinyl and draped with that crinkly disposable wax paper so you don't worry about the prior patient's ailment. The magazine assortment provided in Stalag 2 is even less generous, with older issues than in Holding Pen No. 1. That leaves only a few accessories to hold my attention. Arranged on the counter top next to the sink: a jar with tongue depressors, another with cotton balls and one with a few inches of isopropyl alcohol. Adjacent is the triangle-shaped mallet for reflex testing and that sophisticated flashlight to peer in your ear and up your nose. In addition, a rubber glove and a tube of KY jelly for what purpose I can't imagine. They seem to have done away with the leeches.

I'm mentally comparing my own dental treatment room with its $75,000 worth of equipment to the monk-like austerity of my current cell. If I weren't ill when I came in, a bout of clinical depression might occur. The nurse abruptly returns – probably from lunch – and interrupts my reverie with the command to open my mouth for the thermometer. "I'll be back in a moment," she lies.

During the next 15 minutes of restlessly pacing my little enclosure in random patterns, I rotate the thermometer from side to side like an all-day sucker and take it out occasionally to see how I'm doing. You'd think, after 200 years, somebody would have made an oral thermometer that could be read by people with 20/20 vision. This one seems permanently affixed at 98.6, what else? I'm tempted to throw a little drama into the proceedings by holding a Zippo under the thing for a few seconds, or dunking it in the alcohol and blowing on it, but Ms. Nightingale's arrival thwarts me.

"Doctor will be with you in a moment," she chuckles, pleased that everything is going according to the Master Plan of Patient Subjugation. And sure enough, in less time than it took to ratify the 18th Amendment, The Man himself enters, wearing a stethoscope about his neck, like the sommelier in an expensive bistro.

"Take off your shirt," he states, cutting right to the chase and skipping the part about being devastated for keeping me waiting and begging my forgiveness. All the snippy remarks I rehearsed are tempered by a lack of opportunity to express them between the tongue blade invasion and the up-your-nose scope. Besides, you just can't tear into The Doctor for not having mastered the art of patient management. Getting him annoyed at you is certainly not in your best interests, even with the KY jelly. Probably Hippocrates got the idea for his Oath from hearing a few from his waiting patients.

You go see the doctor, you wait and you do it in special rooms built just for that purpose. That's the way it works; that's tradition. If you want to run the risk in your own dental practice of appearing not busy and important, you might try considering the radical idea that patients' time is as critical to them as your time is to you.

Nah, it would never work!