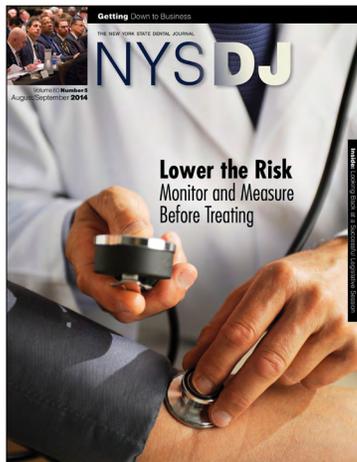


# NYS DJ

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## On a Rainy Day in June

*A whole lot of good was done by volunteers on a Mission of Mercy.*

**T**he day dawned rainy and cold. I arose at 3:30 a.m. to get ready for the first Mission of Mercy (MoM) event in New York State. I had driven to Troy from Buffalo the evening before so I would be able to get to the event at my appointed time of 5 a.m. for orientation. I was a bit tired, but excited for what was to come. NYSDA and the New York State Dental Foundation sponsored the dental clinic over two days in mid-June to provide free care for people with significant dental disease who couldn't afford to see a dentist. I had volunteered to take part, though I really didn't know what to expect. And, as an orthodontist, I wasn't certain what I could do to help.

The event was held in the sports complex at Hudson Valley Community College. When I arrived, it was still raining. I wondered if the rain would keep patients away. Entering the gym complex, I was met by volunteers, who checked me in and told me where I was to go. I signed up to work in radiology, an area I knew quite well. I can still read an X-ray, and panorex, which I use all the time in my practice, were to be taken on all patients coming for treatment.

Since it was still early, I walked around to get the lay of the land. The ice rink at the complex had been converted to a volunteers lounge, with tables and chairs and food stations. Off to the side there

was an area where volunteers could get a massage if needed—a nice touch, I thought.

From there, I went to the radiology area, where there were four digital panorex machines and four portable NOMAD X-ray devices for taking periapical images. It was a rudimentary setup, but very functional.

Next, I toured the treatment area, located in the gymnasium. It was an amazing sight. There were about 80 to 90 chairs set up, ready for patients. This was no small undertaking, and I marveled at the logistics required to achieve such an elaborate setup. Also located on the treatment floor was a triage area where patients would be seen to determine their level of need and the treatment they would receive. And there was another radiology area with three NOMAD devices available to take any needed X-rays not taken in the prime radiology area.

Patients visiting the MoM were offered hygiene, restorative, periodontal, oral surgical and endodontic treatments. There was a pediatric area for children, a pharmacy and a patient education center. I was quite impressed by this dental “field hospital” and by the number of volunteers on hand to provide the care. I had had my doubts about attending, but this short tour disabused me of any reservations

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quickly. I could sense the good that would occur here.

I went back to the radiology area to get briefed on my duties. It turned out I wasn't the only orthodontist working there. I guess that's the natural place to put us. At 6 a.m., our first patients arrived. Each panorex machine had two dental hygienists and one doctor assigned to it. One hygienist would position the patient in the machine and the other would take the X-ray. The X-ray was then brought up on the computer screen and the doctor would examine it to determine if additional pictures were needed.

I screened about 75 X-rays that morning. I didn't see anything too unusual, though I did get to diagnose a nasal polyp with the help of an oral surgeon. Mostly, however, it was count teeth, look at bone levels and determine if any periapical X-rays were needed. Since every patient was to receive a panorex, all patients requesting treatment went through radiology first. We worked as fast as we could, but, with the number of patients being seen, radiology became a bottleneck. We were the slow car holding up traffic.

All the patients I interacted with were very appreciative of the care they were receiving.

### CORRECTION

In the article "Management of the Dental Patient on Anticoagulant Medication" (Agarwal, et al. June/July 2014: 29-32), it was incorrectly stated that "Warfarin is also known as coumarin." It should have said that warfarin is also known as Coumadin. We regret the error.

ing. I was thanked constantly for being there to help them. No one seemed to think he or she was entitled to treatment.

My shift finished at noon, and I went to see how things were going in the treatment area. The place was humming with activity. All stations were operating at full capacity, and much needed dental work was being provided. Again, I was struck by how grateful the patients were to be receiving care—and how happy everyone seemed to be. I never saw anyone who appeared upset or angry. Most surprising, these people actually were happy to see the dentist! This was a revelation to me. I guess I have become jaded over the years about our great profession. We've all heard derogatory dentist jokes, or endured hurtful statements by non-dentists about how, while it's nothing personal, they hate the dentist. Here were people who appeared to actually like being where they were.

I left the clinic floor to get lunch in the volunteer lounge. Not seeing anyone I knew, I sat at an empty table. Soon, another gentleman joined me. He said he was from New York City, that he had accompanied his wife, a dentist, to the MoM, and was working as a patient escort. We talked about the event and he related how wonderful he thought it was to be helping people in need. I agreed with him. He asked me where I was from and I told him. He seemed impressed that I had come all the way from Buffalo to help out. I told him I was impressed that he would

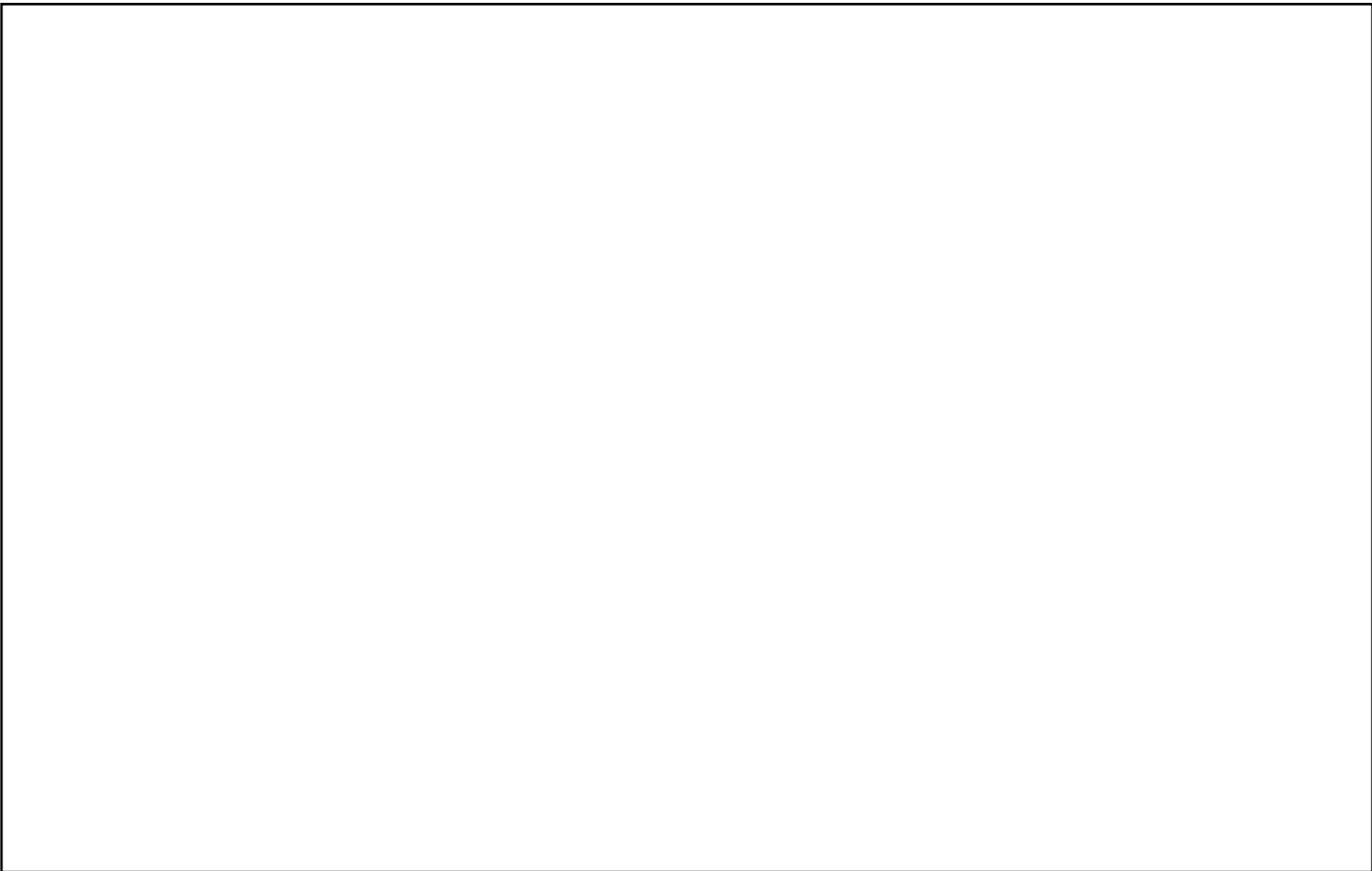
accompany his wife and stay on to help, taking patients from one area to another. He replied, if not him, then who?

And that is what this MoM was all about. If not us, then who? Who would treat these patients? They were there because they couldn't afford to see a dentist. They were the untreated who had fallen through the cracks and desperately needed care. Now, for two days in June in Troy, NY, they had an opportunity to receive needed care from dentists from all over New York State. Over 1,000 patients were treated during this MoM event, and they were treated with care and compassion. Many were relieved of pain for the first time in a long time.

Unfortunately, this is only the tip of the iceberg. There are many other needy patients out there. There is a solution to this problem somewhere. We just need to find it.

I had to leave the MoM that Friday afternoon to return to Buffalo. However, when the next MoM is scheduled in New York State, wherever that might be, I plan to be there. And, I hope, I will be able to contribute both days. It felt good to be a part of this wonderful event. I heartily recommend you volunteer for the next MoM. It will be time well spent, for both you and the patients.

 D.D.S.



# Keeping the Enemy at Bay

## A Recap of the 2014 Legislative Session

*NYSDA can look back with satisfaction on a year that went its way for the most part. But legislative victories are not achieved without a vigilant and astute defense.*

Lance Plunkett, J.D., LL.M.

**I**t is often said that a good defense wins more sporting events than any offense. The 2014 legislative session has come to an end with NYSDA in need of a lot of good defense. Thanks to several key early victories, the Association recorded another successful year. But we often don't focus on the defensive side when tallying victories, though we should, as they are many and equally important.

There is the temptation to assume that every legislative session is the same and that dealing with developments is a matter of routine. This year proved to be quite different. As a result of a very strong behind-the-scenes push by Gov. Andrew Cuomo for a major healthcare initiative to deal with prescription opioid abuse and heroin addiction, suddenly, in the very last week of the legislative session, a slew of healthcare-related bills were introduced and started to move rapidly through both the Senate and Assembly.

While NYSDA supported most of these bills, that was definitely not the case with A.1124-A (Rosenthal) and A.9878 (Rosenthal) / S.7660 (Hannon). This bill would have created a mandatory three-hour continuing education course in opioid prescribing and pain management for healthcare professionals and would have made the course obligatory every two years—on top of the 60 hours already required of dentists. The bill was written only with physicians in mind, but it captured other professionals as well and defied the logic of the three-year licensing cycle—a major technical problem with the bill.

Introduced on May 23 in the Senate and on May 27 in the Assembly, the bill passed the Senate within 10 days and was scheduled for a floor vote in the Assembly. Thanks to grassroots help from members of the New York County Dental Society living in Assembly sponsor Linda Rosenthal's district and a vigorous lobbying effort that included pointing out that the bill ignored the original I-STOP legislation, which called for studying this issue and then providing well-considered recommendations on continuing education needs, NYS-DA was able to derail its rush to passage.

The history of the bill was also very odd. There were two identical versions of it in the Assembly. One, A.9878, had been appropriately referred to the Assembly Higher Education Committee, chaired by Assemblywoman Deborah Glick. That bill was going nowhere as Assemblywoman Glick recognized it was deeply flawed. However, a second, identical version, A.1124-A, also sponsored by Assemblywoman Rosenthal, was simultaneously placed on the Assembly floor calendar for a vote. In addition, the Senate bill, S.7660, which was identical to A.9878 and had passed with remarkable speed and limited notice in the Senate, had been referred to the Assembly Health Committee instead of to the more logical Higher Education Committee, where A.9878 sat.

It was quite clear that there was an effort underway to manipulate rapid passage in the Assembly without going through its Higher Education Committee, which, it appeared, had been given a diversionary identical bill to create the

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Although lobbying was intense right up to the Legislature's adjournment, common sense and clear thinking prevailed in the Assembly.

illusion that the committee was controlling its fate. However, Assemblywoman Glick saw through this and was very helpful in arguing that the bill was flawed and should not be passed without proper vetting through the appropriate Assembly committee. In the end, strong lobbying efforts by NYSDA convinced Assemblyman Richard Gottfried, chair of the Assembly Health Committee, that the bill was a mistake and should not be passed through his committee either.

Although lobbying was intense right up to the Legislature's adjournment, common sense and clear thinking prevailed in the Assembly. It should be noted that NYSDA has two representatives on the I-STOP committee, which was established to study and make recommendations on continuing education concerning pain management and overprescribing of opioid and other controlled substance pain relief drugs. They are Lawrence Duda of the Third District and Steven Tunick of New York County. Their good work should not have been ignored and bypassed by the Legislature. And in the end, it was not.

#### **More Misguided Measures**

Other bills that tried to piggyback on the governor's desire to deal publicly with prescription opioid abuse and heroin addiction were: A.10111 (Rules at request of McDonald) / S.2949-A (Hannon), which would have required healthcare professionals to limit all Schedule II or III controlled drug prescriptions to no more than a 3- to 10-day supply; A.2335-C (Rodriguez) / S.7894 (Carlucci), which would have required a healthcare professional in the Medicaid managed care program to first check with a patient's managed care plan for authorization before issuing any prescription; and S.7918 (Boyle), which would have required healthcare professionals to conduct drug testing of patients before prescribing any narcotic drug. The latter bill died with no Assembly sponsor, although it had some life in the Senate with a Republican sponsor. The impracticality of drug testing patients before prescribing was, apparently, not a particularly appealing option to anyone.

A.2335-C/S.7894, a broad attempt to insert managed care plans into professional prescribing judgments in order to save money in the Medicaid program, never got out of committee in either house of the Legislature. In lobbying against the measure, NYSDA suggested that, despite an elaborate 24-hour a day, seven

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days a week telephone call system requirement in the bill, perhaps, if a dentist could not get through to the patient's Medicaid managed care plan to authorize a prescription, then the patient should instead contact Sen. David Carlucci's office directly.

The third bill, limiting the quantity of Schedule II and III prescriptions, did pass in the Senate, but was never going to pass in the Assembly because Assemblyman John McDonald, a licensed pharmacist, recognized the foolishness of quantity limitations for prescriptions and took control of sponsoring the bill to make sure it did not advance.

### **A Less-than-Tasty Stew**

Not all is as it seems when it comes to legislative proposals. And the motives and actions of legislators are not easily deciphered except by lobbying insiders. The quantity limitation bill, for example, approved by the Senate was part of a series of bills that body passed and dumped on the Assembly to sort out as a program for combatting prescription drug abuse and heroin addiction. In some ways it was like creating a giant stew from which the reasonable, tasty parts needed to be extracted for final passage and the remainder discarded as bad ideas. This approach required constant lobbying and close monitoring in the final days of the session in case an unwholesome part of the stew started to advance—and there were many such parts as illustrated above.

Another last-minute bill that targeted dentistry was S.7915 (O'Brien), a one-house measure that would have called for limiting the ability to take dental X-rays to licensed dental assistants. Since there are only slightly more than 1,200 such licensed dental assistants in New York State, this ill-conceived bill would have crippled most dental practices in the state. Introduced by a lone Democratic senator, with no Assembly counterpart, the bill was doomed from the outset, but it represents a warped mode of thinking on this subject that will bear future watching, especially if the Senate switches to Democratic control next session (more on that below).

### **The Medicaid Conundrum**

A NYSDA success that straddles both defense and offense came early on when it was decided to continue New York's adult dental Medicaid program with no cuts to reimbursements in the State Budget. In fact, honoring a commitment made two years ago, funding for smoking cessation services by dentists in the Medicaid program finally became a reality this year.

Often we hear from members that dental Medicaid reimbursements are so low that to take credit for preserving them is pointless. However, the alternative is zero reimbursement and the elimination of all adult dental services, an optional Medicaid benefit that many states have done away with. The current fiscal reality is that Medicaid is trying to control spending. Calls for more Medicaid spending and for pumping dollars into the

system are doomed under current circumstances and would leave NYSDA a bystander to future Medicaid developments.

Of course NYSDA wants more money for dental Medicaid services, but focusing on that alone will produce no such result. Even at the federal level, when early on there was a Democratic Congress and, by any standards, a liberal Democratic president, nobody was looking to pump more dollars into the Medicaid program. Continuing to call for more dollars now when the political landscape has changed is not actually a legislative strategy—it is just a means to be left on the sidelines when other critical developments in the Medicaid program are being discussed.

NYSDA's Medicaid strategy is far more complex than simply calling for more dollars and has resulted in convincing the state to do things like pay for smoking cessation services. True, payments may not be what all members would like to see, but that isn't a reality limited to just the Medicaid program. Every reimbursement decision is looked at through the prism of ultimate cost savings. And lobbying strategies and arguments need to be tailored to getting money put where it will have beneficial long-term patient healthcare and cost effects. That's how NYSDA is able to stay in the Medicaid arena and showcase the value of dentistry to the overall state healthcare strategy.

NYSDA is also vigilant about the Medicaid program failing to create adequate access to services due to inadequate reimbursements. But under the new Medicaid managed care system, there are no data to support that case. In fact, the New York State Department of Health reports opposite data showing that patients are very satisfied with Medicaid managed care programs and that the program itself is performing splendidly. While this assessment may be a bit too rosy, there isn't evidence to contradict that view. And any lobbying effort depends upon hard data.

### **No Such Thing as a Simple Bill**

Another legislative success with an interesting history was passage of a two-year extension to the restricted dental faculty license law. This law allows dental schools in New York State to more easily recruit faculty members with foreign dental educations by allowing them to obtain licenses to practice that are restricted to their connection to the dental school (Section 6604-b of the New York State Education Law). The law has periodically been set to expire—this time, on Feb. 1—but is now extended to Feb. 1, 2017. The bill passed was A.8660-A (Glick) / S.7183-A (Golden). The governor signed it into law on July 22, as Chapter 172 of the Laws of 2014.

You would think such an innocuous-sounding bill would have smooth sailing, but not so. The Assembly passed very early in the session a version that would have extended the law for four years, until Feb. 1, 2019. However, that bill had no Senate counterpart at the time. When the Senate finally introduced the same bill, sponsored by Sen. Martin Golden, it languished in the Higher Education Committee. The Senate then amended the bill down to just a

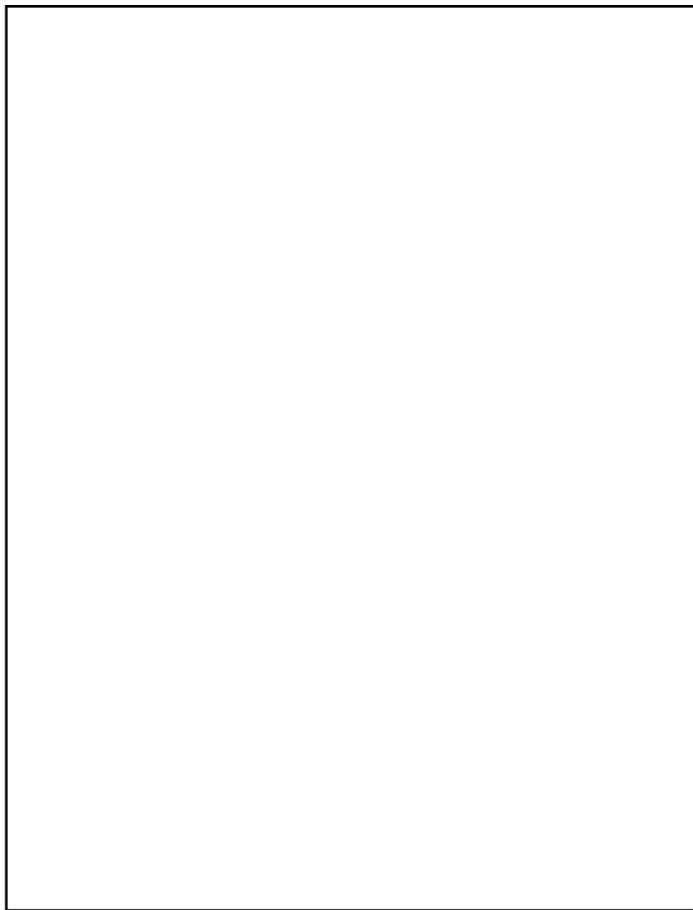
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two-year extension, to Feb. 1, 2017. As a result, the Assembly had to recall its four-year extension bill and vote again, ultimately deciding to agree to the Senate two-year extension version.

The primary advocates for this bill were the Academic Dental Centers, who retain their own lobbyist. But the centers also asked for and received support and assistance from NYSDA. The history of this bill this year illustrates once again that even the simplest seeming item is never really so simple.

### **Supporting the Dental Party**

All manner of malpractice tort reform bills were defeated this year. All of these proposals would have been harmful to dentistry if passed. NYSDA spends considerable time monitoring trial lawyer bills, which have a tendency to start moving toward the end of the legislative session after lying dormant for months. One example is A.1002-A (Weinstein) / S.555-A (DeFrancisco), a seemingly innocuous bill that would allow plaintiffs to recover damages directly from third-party defendants (defendants who the actual named defendant brings into the lawsuit as third-party participants). The current and longstanding rule of law is that a plaintiff cannot directly recover a damage award from a third-party defendant because the plaintiff did not actually sue that person. This bill would alter that longstanding rule to allow direct recovery against third-party defendants.



While such a bill, at first glance, seems to be a harmless and well-intended technical change, the reality is that it would place all malpractice defendants at odds with each other and compromise joint defense of malpractice cases. Fortunately, the Legislature saw the problem and did not pass the bill. However, this measure is one that is constantly being pushed by trial lawyer groups, so it is likely to reappear in future legislative sessions.

Another bill that was defeated was A.5802 (Englebright), a bill that Assemblyman Steven Englebright repeatedly introduces to create the profession of denturology. If allowed to pass, it would license people in a new profession for the sole purpose of making dentures. The bill never makes it out of the Assembly Higher Education Committee because it is a very bad idea that would take dental care in New York State backwards. Nevertheless, NYSDA keeps a watchful eye on it as it might one day spur other similarly bad bills. It should also be noted that the New York State Education Department has no interest in licensing a new profession in this area, especially one that would merely duplicate part of an existing profession, but with inferior education and training and no public need.

Finally, a few words on the changing political picture in New York State alluded to earlier. For the last two legislative sessions, the Senate has had a Democratic majority, but it has remained in Republican control as a result of a power-sharing arrangement with a small group of Democrats known as the Independent Democratic Caucus (IDC). Recently, with Gov. Cuomo and New York City Mayor Bill de Blasio both working hard on a reconciliation, the IDC announced it was going to return to caucusing with the Senate Democrats, which will transfer control of the Senate to Democratic hands next year barring any unusual election results in November.

NYSDA is well-positioned in either scenario for lobbying purposes, but a unified Democratic control of all branches of government does portend significant public policy changes going forward. NYSDA has never looked at government or based its lobbying strategy on Democrats versus Republicans, but considers only whether a legislator is in the “dental party.” Consequently, the Association has forged excellent relationships with supportive legislators from all sides of the political spectrum because its aim is to promote dental policies that advance the health and welfare of the people of New York State. Legislators of many different political stripes support such wise policy and, thus, are members of the dental party rather than being pigeonholed as merely Republicans or Democrats. No other lobbying strategy would bear fruit. And the alternative would be like trying to time the stock market, an effort doomed to failure. //

*The material contained in this column is informational only and does not constitute legal advice. For specific questions, dentists should contact their own attorney. An archive of previously published legal articles can be accessed in the members-only area of the NYSDA website, [www.nysdental.org](http://www.nysdental.org)*

# Clinical Practice and Dental Education

## Can Town Really Meet Gown?

*Dental schools score high marks on preparation of future clinicians.*

Elliott M. Moskowitz, D.D.S., M.Sd

Success in private dental practice would probably be measured differently among practitioners. Financial success, patient and parental satisfaction with the way we manage our practices, the quality and consistency of our treatment outcomes, the quality of our working environment and staff assessment and perceptions of how well they are treated, satisfaction with our own professional and clinical development—do we feel we are acquiring new insights and/or skills, thereby increasing our competency—and, lastly, our relationships with other dental colleagues are important elements contributing to what many of us might consider success in practice. And if for just a moment, we could all agree on the importance of the aforementioned factors, how well are academic institutions preparing tomorrow's clinicians, researchers, educators and leaders in the dental profession for competency and overall success? Is the historical schism between the relevance of dental academic education and clinical practice widening or decreasing?

Among the greatest challenges and advancements in academic instruction has been the introduction of critical thinking skills into the dental educational curriculum. Dental educators have seen the limitations of attempting to teach students “what to think” and instead have shifted the educational emphasis onto “how to think.” Establishing an environment of sound and ethical scientific, research and clinical debate and dialogue is, in my opinion, one of the greatest achievements of modern dental education. Skills learned from this model (similar to the gymnasium system in Europe that prepares students for higher education) prime dental students to manage the rigors and challenges of private practice after graduation.

In addition, the teaching model of individual case conferencing (open dialogue between students and faculty) and the intelligent use of the Internet as a valuable educational resource help students develop the necessary skills for individual patient case diagnosis, treatment planning, ethical management of individual patients, and the need to address oral health issues in our respective communities.

While evidence-based dentistry is a relatively new term for many seasoned dental practitioners, it is an essential and required tool in modern dental education. The EBD process underscores today's teaching and will better prepare dental school graduates to assess current and future protocols, as well as materials and devices that are introduced to the dental profession, often with extravagant claims that are unsubstantiated by high-quality evidence and, all too frequently, have been disappointing in the clinical environment. It will also give the practicing clinician an opportunity to participate in this process as practice-based research networks (PBRN), which, although utilized in medicine for many years, are in their infancy in the dental profession.

In the past, clinicians have always considered the dental student to be an individual in need of an extraordinary learning curve to help him or her transition from the academic environment to the clinical setting, or “real world” of dentistry. Current dental education has helped bridge this perceived disconnect between these two distinct environments. The academic environment has always been the real world of dentistry, no more or less than private clinical practice.

Dentistry remains a “hot profession,” and admittance is highly competitive. We are attracting the very best that colleges have to offer, and the profession can be assured that the current pool of talented predoctoral and postdoctoral students/residents will ensure a bright and successful future for the dental profession.

So how are our dental schools doing in preparing the younger generation of dentists for the challenges of delivering high-quality oral healthcare to the public? I'd say quite well—very, very well, in fact. ✎



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# Attitudes toward Monitoring Blood Pressure and Blood Sugar at a New York State Dental School

Jacqueline M. Tuthill, D.D.S.; Samantha J. Smith, D.D.S.; Michael N. Hatton, D.D.S., M.S.;  
Robert Dunford, M.S.

## ABSTRACT:

**The aim of this retrospective study was to assess dental patient, physician and dental student attitudes toward blood pressure and glycemic monitoring within a dental school environment. The responses of these cohort groups were analyzed by using an Institutional Review Board-approved survey. Physicians and dental students viewed blood pressure monitoring positively, while patients were less enthusiastic. All three groups viewed measuring blood sugar on diabetic patients prior to dental surgery as important, but not on a routine basis.**

According to the Centers for Disease Control, “About 1 in 3 U.S. adults—or 67 million people—has high blood pressure. Only about half (47%) of people with high blood pressure have their condition under control. Hypertension is the most common condition seen in primary care and leads to myocardial infarction, stroke, renal failure, and death if not detected early and treated appropriately.”<sup>1</sup>

As early as 1977, the Coordinating Committee of the National High Blood Pressure Education Program identified a need for communication between all health professionals and patients regarding hypertension diagnosis and management.<sup>2</sup>

The American Dental Association has provided guidance on dental patients and hypertension for many years.<sup>3</sup> A seminal article in 2004 stated: “All health care providers, including dentists and members of the dental team, need to be involved in detection and management of this important public health problem. The dentist can play an important role in the detection and management of hypertension.”<sup>4</sup>

And in a review article published in 1997, Muzyka and Glick wrote: “Pre-procedural monitoring of blood pressure is recommended for all patients and is especially important for those with a diagnosis of hypertension. Dental practitioners who find large variation from normal blood pressure ranges should report the results to the primary health care practitioner, and ask the patient if he or she is complying with the treatment protocol. Dental practitioners should measure blood pressure at every visit for known hypertensive patients and at least once per year for all other patients without cardiovascular risk factors.”<sup>5</sup>

The American Diabetes Association found 25.8 million people in the United States have diabetes (8.3% of our population). Of that number, 7 million are unaware they have diabetes. Further, 79 million people are pre-diabetic. In 2010, 1.9 million new cases of diabetes were diagnosed in people aged 20 years and older. In addition, 67% of adults above the age of 20 with self-reported diabetes had a blood pressure equal to

or greater than 140/90 or used prescription medications for hypertension. The risk of developing heart disease or stroke is two- to four-times higher for diabetic patients than non-diabetic patients.<sup>6</sup> Dental concerns for the diabetic patient have been articulated recently.<sup>7</sup>

At the University at Buffalo School of Dental Medicine (UB-SDM), dental students monitor blood pressure (BP) and random capillary blood glucose/sugar (RBG). These values are obtained on all diabetic patients at every visit as a matter of school protocol.

Our goals are as follows:

- To reduce medical risks of performing a dental procedure on any patient, whether medically compromised or not.
- To familiarize dental students with easily measured systemic health parameters so, in turn, they can use these techniques in their practices.
- If a medical emergency should happen during patient care, there are known starting parameters from which to formulate a differential diagnosis.
- To reduce the incidence of hypoglycemia and its attendant morbidity.
- To instill in dental students the concept that “taking good care” of their patients’ global health engenders mutual trust and confidence.

If measurements for BP or RBG are deemed unacceptable by our oral medicine faculty, the dental student will fax a letter to the patient’s physician. After an appropriate response from the physician, a decision is made on whether to treat the patient for elective care.

This study involved an anonymous, retrospective survey of patients, students and physicians collectively involved in our school’s care. We hypothesized that all three cohorts would view BP and RBG monitoring as having a positive impact on the patient’s global health. Although this rationale seems obvious, we found little data in the literature that measures these views in a dental school environment.

## Methods

Subjects were selected based on a chart review using the patient database at UB-SDM (Table 1-1). Patients with a diagnosis of hypertension and/or diabetes were identified. These charts were further selected for evidence of written communication between the dental student and the patient’s physician. Approximately 2,300 charts were reviewed.

Dental students (105), patients (141) and physicians (124) were sent anonymous survey questions (Table 1-2). All returned questionnaires were de-identified. Responses were color coded to indicate whether the response was from a physician, student or patient. Responses from the three groups were analyzed by Pearson chi-square test, degrees of freedom (=2); Mini Tab statisti-

**TABLE 1.**  
Selection Criteria for Survey Participants, Survey Questions, Statistical Analysis

### 1. Survey Participant Selection

Inclusion Criteria	Exclusion Criteria
<ul style="list-style-type: none"> <li>● Patient with hypertension and/or diabetes</li> <li>● Copy of fax sent to physician present in chart</li> </ul>	<ul style="list-style-type: none"> <li>● Diabetes and/or hypertension was not the primary reason for communication</li> <li>● White coat syndrome</li> <li>● Death</li> <li>● No documentation of communication</li> </ul>

### 2. Sample Survey Questions

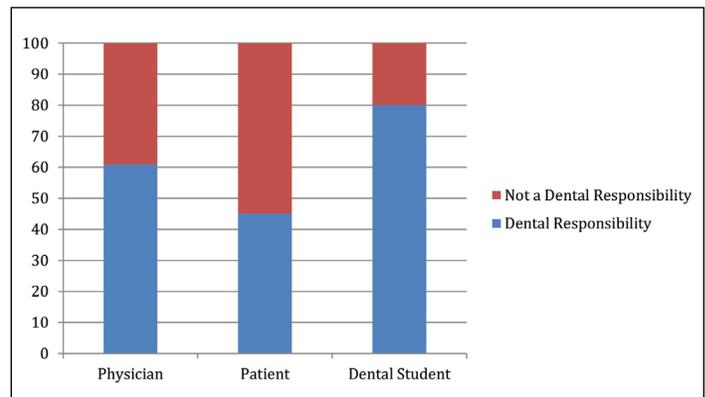
Hypertension	Diabetes
<ul style="list-style-type: none"> <li>● In your opinion, does monitoring blood pressure for patients at the dental school have a positive impact on your patient’s systemic health?</li> <li>● In your opinion, is it the responsibility of a dentist to measure blood pressure prior to dental treatment?</li> </ul>	<ul style="list-style-type: none"> <li>● In your opinion, does monitoring blood glucose for diabetic patients at the dental school have a positive impact on your patient’s systemic health?</li> <li>● In your opinion, is it the responsibility of a dentist to measure blood glucose (on diabetic patients) prior to dental treatment?</li> </ul>

### 3. Statistical Analysis

<ul style="list-style-type: none"> <li>● Pearson’s Chi Square Test</li> <li>● Degrees of Freedom</li> <li>● P-Value</li> </ul>
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**TABLE 2.**  
Survey Questions Relating to Dental Responsibility of Measuring BP Prior to Treatment (Figure 1)

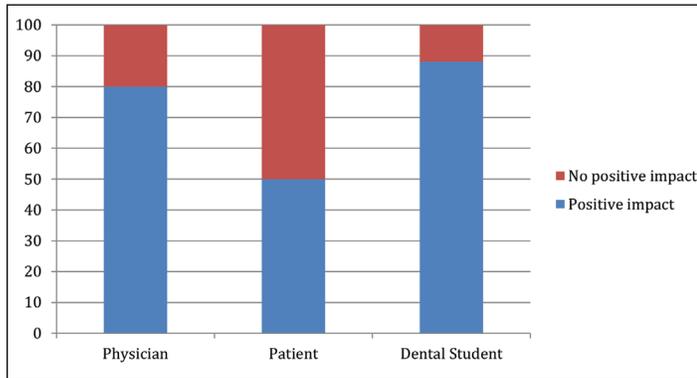
Physician	Patient	Dental Student
In your opinion, is it the dentist’s responsibility to measure blood pressure prior to dental treatment?	In your opinion, is it the dentist’s responsibility to measure blood pressure prior to dental treatment?	In your opinion, is it the dentist’s responsibility to measure blood pressure prior to dental treatment?
A) No B) Not Sure C) Yes	A) No B) Not Sure C) Yes	A) No B) Not Sure C) Yes



**Figure 1.** Percent of cohort members who felt measuring BP was dental responsibility, or was not dental responsibility. Chi-square analysis, P-value < 0.05.

**TABLE 3.**  
**Survey Questions to Determine whether BP Measurement Prior to Dental Treatment has Positive Impact on Patient's Global Health (Figure 2)**

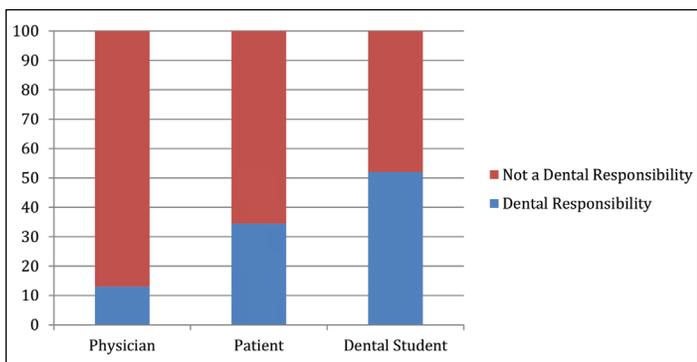
Physician	Patient	Dental Student
In your opinion, does measuring a patient's blood pressure have a positive impact on the overall health of the dental patient?	In your opinion, does measuring blood pressure have a positive impact on your overall health?	In your opinion, does measuring a patient's blood pressure have a positive impact on the overall health of the dental patient?
A) No B) Not Sure C) Yes	A) No B) Not Sure C) Yes	A) No B) Not Sure C) Yes



**Figure 2.** Percent of cohort members who felt measuring BP prior to dental treatment had positive impact. Chi-square analysis, P-value <0.05.

**TABLE 4.**  
**Survey Questions to Determine whether it is Dental Responsibility to Measure RBG on Diabetic Patients Prior to Dental Treatment (Figure 3)**

Physician	Patient	Dental Student
In your opinion, is it the dentist's responsibility to measure a diabetic patient's blood sugar prior to initiating dental treatment?	In your opinion, is it the dentist's responsibility to measure a diabetic patient's blood sugar prior to initiating dental treatment?	In your opinion, is it the dentist's responsibility to measure a diabetic patient's blood sugar prior to initiating dental treatment?
A) No B) Not Sure C) Yes	A) No B) Not Sure C) Yes	A) No B) Not Sure C) Yes



**Figure 3.** Percent of cohort members who believed measuring random RBG was dental responsibility. Chi-square analysis, P-value < 0.05.

cal software was used to obtain P values. Responses of “no” and “not sure” were considered negative answers, while responses of “yes” were considered supportive of the question asked. We used Chi-square analysis to determine if differences existed among responses from the three cohort groups. P-values < 0.05 were considered to be statistically significant.

### Results

We received a 23.8% (n=25) response from dental students, 44.7% (n=63) response from patients and 20% (n=25) response from physicians. Eighty percent of dental students, 61% of physicians and 45% of patients believed measuring BP was a dental responsibility (Table 2, Figure 1). Eighty-eight percent of dental students, 80% of physicians and 50% of patients felt measuring BP prior to dental treatment had a positive impact on the patient's well-being (Table 3, Figure 2).

### RBG Measurement

Fifty-two percent of dental students, 34% of patients and 13% of physicians felt that measuring RBG was a dental responsibility (Figure 3). Seventy-two percent of dental students, 40% of patients and 62% of physicians felt that obtaining RBG prior to dental treatment had a positive impact on patient health (Figure 4). Ninety-two percent of physicians, 92% of dental students and 65% of patients felt that taking RBG before dental surgery was important (Figure 5).

*Note: No statistical difference was seen in responses by cohort age, years in practice (physicians) or zip code.*

### Discussion

Monitoring BP was viewed as a dental responsibility by the majority of dental students surveyed (80%). Greenberg et al. found that 85.8% of dentists were willing to screen for hypertension, similar to our survey of dental students. Greenberg's study also found that 76.6% of dentists were willing to screen for diabetes.<sup>8</sup> Another recent study by Barasch et al. found similar levels of support among dentists and patients for RBG screening.<sup>9</sup> We found less support (52%) for RBG monitoring as a dental responsibility among our dental students. In contrast to Barasch's study, only 40% of our patients viewed routine RBG monitoring positively as being a dental responsibility.

Our study also found a low percentage of physician enthusiasm (12%) for routine RBG monitoring. However, our written communications with physicians do not clearly state that prevention of hypoglycemia is the major reason we measure blood sugar on all diabetic patients. Therefore, physician responses may have been more favorable if they knew this important factor. Our data does show wide support by physicians for the school to measure RBG prior to “dental surgery.” Perhaps the connotation of the word “surgery” in the question prompts this support.

If our patient's blood sugar reading is below 80 mg/dL, we give the patient an oral sugar bolus (fruit juice) prior to commencing the procedure. We again measure RBG after oral sugar administration. Students will also re-measure RBG if symptoms of hypoglycemia occur, or at the terminus of a lengthy dental procedure. Since UB-SDM initiated this protocol, we have had very few instances of hypoglycemia in our diabetic population.<sup>10</sup>

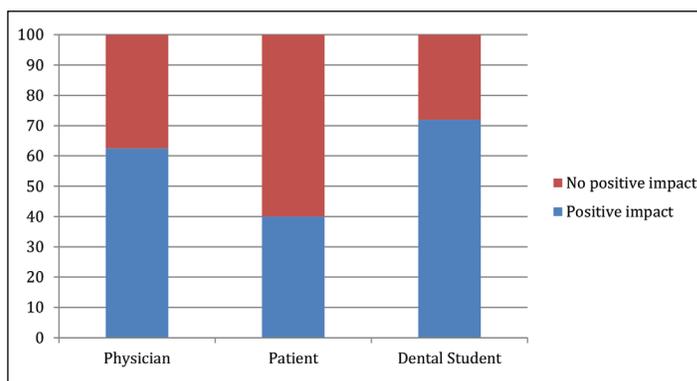
It is noted that most U.S. dentists are not required to measure BP on any patient, or obtain RBG measurements on their diabetic patients prior to local anesthesia administration. The lack of preoperative data regarding BP and RBG in dental patients can potentially make management of medical emergencies more complicated.<sup>11</sup> Administration of local anesthesia can potentiate a systemic vasoactive response. Yet, we cannot find literature mandating BP (or RBG) measurement prior to the administration of local anesthesia in dentistry. Barasch reports that measuring blood glucose levels does not seem widespread among dentists. And Malamed states, "heart rate/rhythm should be monitored as a routine part of all dental visits. Dental insurance carriers have reported that only 2% of general dentists record vital signs regularly. It is the standard of care within the medical profession to record vital signs prior to the injection of any drug."<sup>12</sup>

Oral and maxillofacial surgeons are "required" to measure vital signs, as we found in the Parameters of Care for Oral and Maxillofacial Surgery.<sup>13</sup> The Texas State Dental Practice Act states that dentists "should" measure vital signs, but is unclear as to how often, and what should be done if aberrancies are discovered. No mention is made of RBG determination being required for diabetic patients in these documents. Determinations of BP and RBG on all dental patients are skills that dentists can easily learn and acquire. UB-SDM internal records indicate that routine monitoring of blood pressure and random blood glucose monitoring have greatly reduced the incidence of medical emergencies at our institution.

Besides blood pressure and blood sugar monitoring, novel innovations in sialometric diagnosis are now commercially available.<sup>14</sup> Dentists have a prime opportunity not only to monitor systemic disease, but also to screen for systemic diseases through salivary analysis.<sup>15</sup> Oral fluid testing includes HIV, H1N1, genomic analysis and many other bio-markers found in saliva.<sup>16</sup> At the School of Dental Medicine at Buffalo, for example, we have screened over 950 dental school patients for HIV using a rapid, oral fluid-based test (*Ora-Sure Technologies*). We found that patients and dental students readily embrace oral fluid-based HIV screening, apart from their dental care. Based on our findings (publication in progress), it is our firm opinion that the dental profession should consider screening for systemic disease through new oral fluid-based technologies.

**TABLE 5.**  
Survey Questions to Determine whether Measuring RBG prior to Dental Treatment has Positive Impact on Patient's Health (Figure 4)

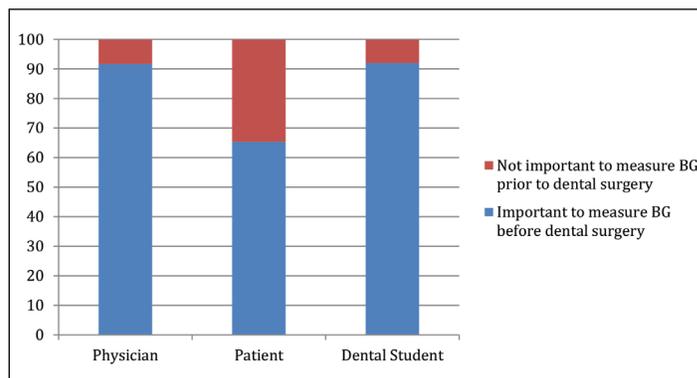
Physician	Patient	Dental Student
In your opinion, does measuring blood sugar on diabetic patients, prior to dental treatment, have a positive impact on your patient's global health?	In your opinion, does measuring blood sugar on diabetic patients, prior to dental treatment, have a positive impact on your global health?	In your opinion, does measuring blood sugar on diabetic patients, prior to dental treatment, have a positive impact on your patient's global health?
A) No B) Not Sure C) Yes	A) No B) Not Sure C) Yes	A) No B) Not Sure C) Yes



**Figure 4.** Percent of cohort members who believed measuring RBG prior to dental treatment has a positive impact on their health. Chi-square analysis, P-value < 0.05.

**TABLE 6.**  
Survey Questions by Cohort Related to Importance of Measuring RBG Prior to Dental Surgery (Figure 5)

Physician	Patient	Dental Student
Do you think it is important to take a diabetic patient's blood sugar before dental surgery?	Do you think it is important to take a diabetic patient's blood sugar before dental surgery?	Do you think it is important to take a diabetic patient's blood sugar before dental surgery?
A) No B) Not Sure C) Yes	A) No B) Not Sure C) Yes	A) No B) Not Sure C) Yes



**Figure 5.** View of cohort members on importance of measuring RBG prior to dental surgery. Chi-square analysis, P-value < 0.05.

## Conclusions

Dental students and physicians view blood pressure monitoring as a dental responsibility favorably. Patients did not share as high an opinion, but almost half of our patients thought blood pressure monitoring was beneficial to their health. Physicians were less enthusiastic about monitoring random blood glucose among their diabetic patients.

We believe that blood pressure should be monitored on all dental patients. We also believe that random blood glucose should be measured on known diabetic patients prior to any dental procedure. It clearly makes for good practice from a risk management standpoint. Dental students, patients and physicians gain mutual trust and confidence through the profession's efforts to monitor markers of systemic health among dental patients. //

Queries about this article can be sent to Dr. Hatton at [hatton@buffalo.edu](mailto:hatton@buffalo.edu).

## REFERENCES:

1. CDC. Vital signs: awareness and treatment of uncontrolled hypertension among adults—United States, 2003–2010. *MMWR* 2012;61(35):703–9.
2. Report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure. *JAMA* 1977;237(3):255–261.
3. Burch GE, DePasquale NP. Arterial hypertension and the dental patient. *JADA* 1966;73(1):102–106.
4. Herman W, Konzelman J, Prisant L. New national guidelines on hypertension: a summary for dentistry. *JADA* 2004;135:576–584.
5. Muzyka BC, Glick M. The hypertensive dental patient. *JADA* 1997;128(8):1109–1120.
6. Centers for Disease Control and Prevention. National diabetes fact sheet: national estimates and general information on diabetes and pre-diabetes in the United States, 2011. <http://www.cdc.gov/DIABETES/pubs/factsheet11.htm>—Accessed 5/22/2014.
7. Genco RJ, Schifferle RE, Dunford RG, Falkner KL, Hsu WC, Bulukjian J. Screening for diabetes mellitus in dental practices. *JADA* 2014;145:57–64.
8. Greenberg BL, Glick M, Frantsve-Hawley J, Kantor ML. Dentists' attitudes toward chairside screening for medical conditions. *JADA* 2010;141:52–62.
9. Barasch A, Qvist V, Palmore R, Gesko D, Gilbert G. Random blood glucose testing in dental practice. *JADA* 2012;143:262–269.
10. Anders PL, Comeau RL, Hatton MN, Neiders ME. The nature and frequency of medical emergencies among patients in a dental school setting. *J Dent Educ* 2010;74:392–396.
11. Malamed, SF. Medical Emergencies in the Dental Office. St. Louis, MO: Mosby, 2007.
12. Malamed SF. Dimensions of Dental Hygiene. 2009;7(1):24,26.
13. Miloro M, DeLeeuw KA, Ruggiero SL. Parameters of care for oral and maxillofacial surgery. *J Oral Maxillofac Surg* 2012;70(11): e12–e30.
14. Wong DT. Salivary diagnostics powered by nanotechnologies, proteomics and genomics. *JADA* 2006; 137(3): 313–321.
15. Malamud D, Rodriguez-Chavez IR. Saliva as a diagnostic fluid. *Dent Clin North Am* 2011;55(1):159–178.
16. Giannobile WV. Salivary diagnostics for periodontal diseases. *JADA* 2012 143(suppl 10): 6S–11S.

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# Granular Cell Tumor

## A Case Report

Michael Shapiro, D.D.S.; Louis Mandel, D.D.S.

### ABSTRACT

**The granular cell tumor, a non-specific, slow growing nodule usually affecting the tongue, is best regarded as having a reactive/metabolic origin rather than a neoplastic one. Histogenetically, it is thought to develop from neural cells. Definitive diagnosis is only obtained after histologic examination of a tissue specimen.**

The granular cell tumor (GCT), first described by Abrikossoff,<sup>1,2</sup> is an uncommon lesion that has a special predilection for the oral cavity. Although it can develop in multiple locations, including the respiratory, gastrointestinal and urinary systems, 45% to 65% of these lesions occur in the head and neck area, while 70% of them are intraoral, usually involving the tongue.<sup>2-8</sup> The GCT is a slow-growing, non-ulcerating nodule that is asymptomatic in its manifestations. It may be seen as solitary or multiple nodules with 10% to 25% of the nodules being reported as multiple in presentation.<sup>2,6,9,10</sup> The GCT most commonly occurs in the fourth to sixth decades of life,<sup>3,7-10</sup> and has a propensity to affect females in ratios of 2:1, or even 3:1.<sup>2,7,9,11-13</sup>

Intraorally, the GCT is a non-specific mass, usually less than 3 cm in size, involving the dorsum of the tongue, with most near

the midline.<sup>4,7,8,14</sup> The growth is submucosal in nature, poorly circumscribed and painless, but very firm and fixed in its location when palpated. The overlying mucosal epithelium is intact, but tends to have a gray or yellow hue.<sup>2,4</sup>

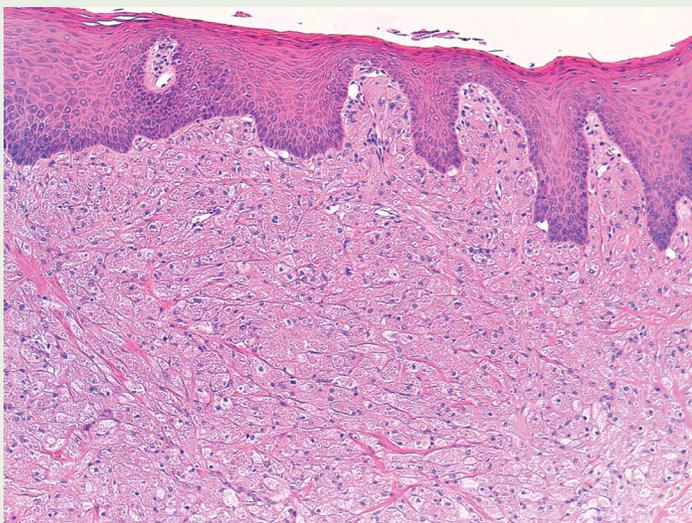
Skeletal muscle was originally implicated as the histogenetic origin of the GCT by Abrikossoff.<sup>1,2</sup> However, this theory of origin is no longer accepted. Generally, it is now thought to originate from the Schwann cells of the neural sheath. Altered metabolism of Schwann cells represents the prevalent theory because immunohistochemistry of the GCT cells demonstrate the biomarkers S-100, vimentin and the neuron-specific enolase (NSE), all of which are present in neural cells.<sup>4,6,7,9,10,14-17</sup> Nevertheless, a neuroendocrine origin has also been suggested in view of the fact that NSE is a neuroendocrine marker.<sup>7,13,17,18</sup> Although the GCT reacts to neural markers, no specific marker for GCT has been found.<sup>7,13</sup>

The GCT can be regarded as a local metabolic or reactive change rather than a true neoplasm.<sup>13,17,19</sup> Histologically, the lesion is poorly circumscribed, with no apparent encapsulation. Nests and ribbons of large polygonal cells, with a granular eosinophilic and abundant cytoplasm, are observed. The nuclei are small, dense and tend to be excentrically located. The cellular

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**Figure 1.** Clinical appearance of granular cell tumor at anterior tip of tongue.



**Figure 2.** Microscopic view of excised specimen (magnification x100, H and E stain).

groups are separated by fibrous septae, while the individual cell borders are indistinct.<sup>17</sup> There is little mitotic activity. In approximately 50% of the GCTs, the overlying epithelium will demonstrate a reactive pseudoepitheliomatous hyperplasia,<sup>2,3,6,7,10,15</sup> a benign epithelial change that often is microscopically misinterpreted as a squamous cell carcinoma. Malignancy of the GCT has been reported to occur in 1% to 3% of the total cases,<sup>2-4,19</sup> but rarely in the oral cavity.

Laser excision has been suggested,<sup>2</sup> but local surgical excision with a safety margin appears to be the most frequently advocated therapeutic approach. Of interest is the fact that 40% to 55% of the lesions that had been locally excised showed the excisions were inadequate, because tumor cells were present at the margins of the excised specimen.<sup>14,17</sup> Regardless, follow-up of these cases revealed no recurrences. This observation would seem to indicate regression of the residual GCT cells, thus lending credence to the hypothesis that the GCT is not a true neoplasm and may indeed be a metabolic/reactive lesion.

### Case Report

A 38-year-old Hispanic-American female was referred to the Columbia University College of Dental Medicine Oral and Maxillofacial Surgery Clinic by her general dentist because of a small, flat, yellowish, circumscribed nodule on the dorsal anterior tip of the tongue (Figure 1).

A medical history indicated that the patient was in excellent health. She has occasionally used sedatives to facilitate sleep. The patient said she was unaware of the lesion until her dentist called it to her attention. Consequently, its duration was unknown. The patient denied traumatizing the tip of the tongue by biting or with a tongue-thrust habit. There was no subjective pain associated with the lesion.

Intraorally, the mucosal tissues were normal in appearance. At the anterior dorsal tip of the tongue, a yellow, circumscribed discoloration was noted. Measuring about 4 mm in diameter, it was found to be painless and firm when palpated. Only a slight elevation of the overlying intact mucosa was noted.

Excisional biopsy and histologic examination were performed (Figure 2). Benign appearing stratified squamous epithelium was present on the surface. Beneath the surface, large polygonal cells with abundant eosinophilic granular cytoplasm, arranged in sheets, were present. Mitotic activity and cellular atypism were not evident. The lesion's cells were seen at the lateral and deep margins of the excised specimen. A diagnosis of GCT was made.

### Discussion

Because the GCT is non-specific in appearance, it is rarely diagnosed clinically prior to surgical intervention. Excisional or incisional biopsy is necessary to histologically identify the GCT. Most frequently, the GCT has been misdiagnosed as a traumatic (irritation) fibroma, lipoma or unspecified tumor.<sup>14</sup> Diagnosis of these entities awaits the histologic examination.

The traumatic fibroma is a common oral cavity exophytic growth. It represents a reactive lesion caused by chronic trauma to oral mucosa. When located on the tongue, chronic irritation from repeated bites or a tongue-thrust habit against an irregular surface are assumed to initiate the overgrowth of fibrous connective tissue. A firm fibroblastic mass develops, while the overlying epithelium often becomes hyperkeratotic due to the chronic friction.<sup>20</sup> Our patient denied any history of repetitive trauma, and hyperkeratosis was not present.

Lipomas are common benign asymptomatic neoplasms of mature adipose tissue. They are infrequently found in the oral cavity, but, occasionally, are located on the tongue.<sup>21</sup> They are encapsulated and soft in consistency, in contrast to the GCT, which is not encapsulated and quite firm when palpated. Confusion in clinical diagnosis occurs because this neoplasm of fat cells has a yellowish clinical appearance similar to the GCT.

It is apparent that a successful, total removal of the GCT was not achieved in our case. Lesional cells were microscopically reported to be present at the margins of the excised tissue. If the GCT represented a true neoplasm, a second, wider surgical intervention would be required. However, the GCT probably is not representative of a neoplasm. As indicated, previous reports state that about one-half of the excised GCTs have lesional cells at the margins of the removed specimen. Yet, follow-up studies failed to reveal recurrences,<sup>14,17</sup> probably because the GCT represents a reactive/metabolic cellular proliferation rather than a true neoplasm. Further substantiation of this theory can be derived from the fact that encapsulation, as seen in benign growths, is not observed. Although a small percentage of GCTs are malignant, recognition of their existence is best made when active mitosis, necrosis and cellular pleomorphism are noted. Our patient presented no such pattern. Nevertheless, the need for continued follow-up was impressed upon our patient.

The pseudoepitheliomatous hyperplasia seen in 50% of GCTs was also not observed in our patient. Awareness of the existence of this tissue change is mandatory because there have been occasions where this epithelial alteration has been falsely interpreted as a squamous cell carcinoma.

## Conclusion

The GCT is thought to be a reactive/metabolic cellular growth rather than a true neoplasm. At the present time, it is generally accepted to originate from Schwann cells of the neural sheath. Definitive diagnosis awaits the microscopic study of the excised lesion. ✍

Queries about this article can be sent to Dr. Mandel at LM7@columbia.edu.

## REFERENCES

- Zangari F, Trombelli L, Calura G. Granular cell myoblastoma. Review of the literature and report of a case. *Minerva Stomatol* 1996;45:231-7.
- Becelli R, Perugini M, Gasparini G, Cassoni A, Fabiani F. Abrikossoff's tumor. *J Craniofac Surg* 2001;12:78-81.
- Kyrmizakis DE, Nikolidakis AA, Panayiotides JG, Christodoulou P, Helidonis E. Lingual granular cell tumor. *Otolaryngol Head Neck Surg* 2001;124:422-3.
- Nagaraj PB, Ongole R, Rao BRB. Granular cell tumor of the tongue in a 6-year-old girl. A case report. *Med Oral Patol Oral Cir Bucal* 2006;11:e162-4.
- Lopez-Jornet P. Granular cell tumor of the tongue. *NY State Dent J* 2008;74:71-2.
- Fitzhugh VA, Maniar KP, Gurudutt VV, Rivera M, Chen H, Wu M. Fine-needle aspiration biopsy of granular cell tumor of the tongue: a technique for the aspiration of oral lesions. *Diagn Cytopathol* 2009;37:839-42.
- Haikal F, Maceira JP, Dias EP, Ramos-e-Silva M. Histogenesis of Abrikossoff tumour of the oral cavity. *Int J Dent Hyg* 2010;8:53-62.
- Sena Costa NC, Bertini F, Carvalho YR, Almeida JD, Cavalcante ASR. Granular cell tumor presenting as a tongue nodule: two case reports. *J Med Case Rep* 2012; 6:56.
- Wroblewski ME, Washing DJ, Zaher A. Pathologic quiz case. *Arch Pathol Lab Med* 2004; 128:1059-60.
- Bomfim LE, Alves F, de Almeida OP, Kowalski LP, Perez DE. Multiple granular cell tumors of the tongue and parotid gland. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009; 107: e10-13.
- Gursoy B, Energin K. Granular cell tumour (a case report). *J Marmara Univ Dent Fac* 1997; 2:631-3.
- Brannon RB, Anand PM. Oral granular cell tumors: an analysis of 10 new pediatric and adolescent cases and a review of the literature. *J Clin Pediatr Dent* 2004; 29:69-74.
- Barbieri M, Musizzano Y, Boggio M, Carcuscia C. Granular cell tumour of the tongue in a 14-year old boy: case report. *Otorhinolaryngol Ital* 2011;31:186-9.
- Munhoz EA, Moreira CR, Soares CT, Rubira-Bullen RF, Sant'Anna E, Damante JH. Yellowish plaque in the tongue: a case report in child. *Am J Otolaryngol* 2008; 29: 414-6.
- Eguia A, Uribarri A, Escoda CG, Crovetto MA, Martinez-Conde R, Aguirre JM. Granular cell tumor: report of 8 intraoral cases. *Med Oral Patol Oral Cir Bucal* 2006; 11: e425-8.
- Angiero F, Crippa R, Stefani M. Granular cells tumour in the oral cavity: report of eleven cases treated with laser surgery. *Minerva Stomatol* 2006;55:423-30.
- Vered M, Carpenter WM, Buchner A. Granular cell tumor of the oral cavity: updated immunohistochemical profile. *J Oral Pathol Med* 2009;38:150-9.
- Williams HK, Williams DM. Oral granular cell tumours: a histological and immunocytochemical study. *J Oral Pathol Med* 1997;26:164-9.
- Rejas RA, Campos M-S, Cortes A-R-G, Pinto DS, Machado de Sousa S-C-O. The neural histogenetic origin of the oral granular cell tumor: An immunohistochemical evidence. *Med Oral Patol Oral Cir Bucal* 2011;16: e6-10.
- Dayan D, Bodner L, Hammel I, Wolman M. Histochemical characterization of collagen fibers in fibrous overgrowth (irritation fibroma) of the oral mucosa; effect of age and duration of lesion. *Arch Gerontol Geriatr* 1994;18:53-7.
- Lee S-H, Yoon H-J. Bilateral asymmetric tongue classic lipomas. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2012;114: e15-8.

# Sequential Years of Dental Outreach to Jamaica

## Gains toward Improved Caries Status of Children

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### ABSTRACT

**In the years 2007 to 2011, faculty, pediatric dental residents and dental students lead by New York University College of Dentistry and Healthcare International Reachout, Inc., traveled to the Hoolebury School, Saint Ann Parish, Jamaica, where they provided treatment to 172 children. The service project focused on dental health promotion, education and prevention. Although not a randomized controlled trial, the statistical evidence from records of treatment received and the presence of decay strongly suggests the positive benefit of repeat dental visits and the placement of sealants on permanent molars in these children.**

Dental caries is the most common disease among children and greatly alters the quality of life.<sup>1</sup> Caries prevention techniques have proved to be rewarding.<sup>2-4</sup> Studies have shown that early intervention with preventative treatment, such as pit and fissure sealants and fluoride, may help reduce the amount of childhood caries.<sup>5,6</sup> Sealant and prevention programs appear to reach at-risk

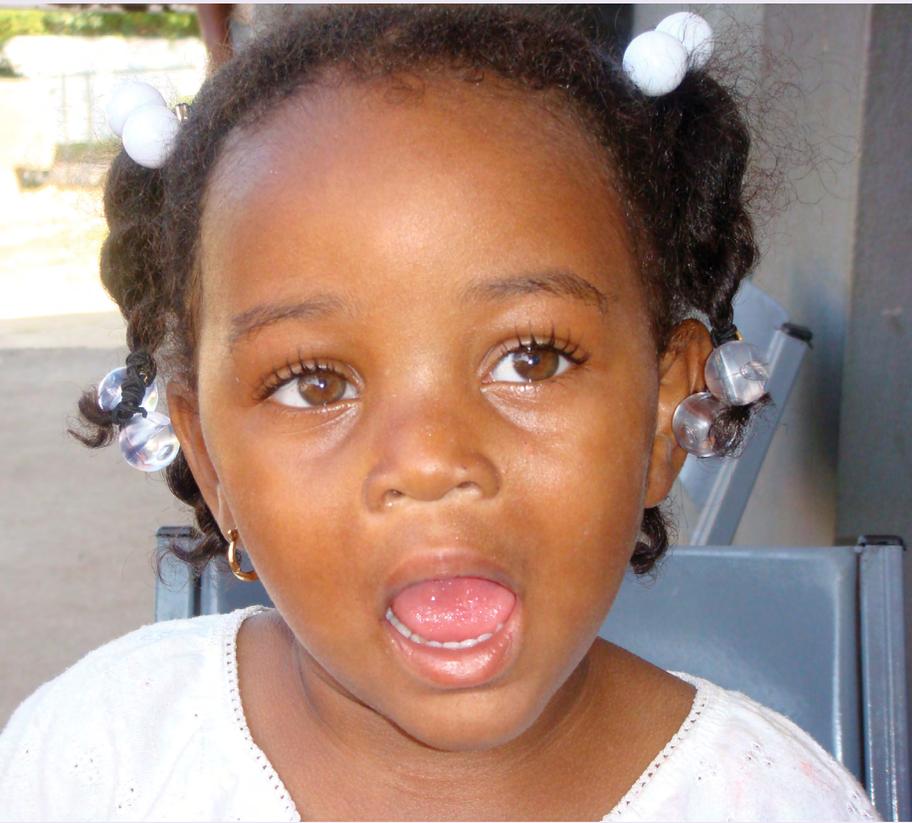
populations and to be cost-effective in comparison to alternatives.<sup>7-10</sup>

Since their introduction to dentistry in the 1960s, sealants have successfully protected the occlusal surfaces of teeth from decay-causing bacterial growth in children at all risk levels.<sup>11,12</sup> When properly placed, sealants may have a protection efficiency of close to 100%.<sup>13-15</sup>

In addition to sealants, fluoride varnish application has been an effective ally in lessening the prevalence of dental caries.<sup>1</sup> Biannual application of fluoride varnish can reduce decay by 38%.<sup>16</sup> Fluoride varnish has the added benefits of requiring a simple, non-technique-sensitive application; causes little discomfort; and its prolonged exposure time<sup>1</sup> allows maximum fluoride uptake into enamel.<sup>16,17</sup>

### Materials and Methods

In the years 2007 to 2011, New York University College of Dentistry and Healthcare International Reachout, Inc., participated in a service project on dental health promotion, education and prevention at the Hoolebury School, Saint Ann Parish, Jamaica. Faculty, pediatric dentistry residents and dental students completed oral healthcare screenings and provided dental care. Two students, or one student and a pediatric resident, performed each clinical exam. Random inter-rater reliability checks were incorpo-



rated to ensure consistency in diagnosis. All work was checked by a general or pediatric dentistry faculty member.

Children received fluoride varnish, restorative dentistry and extractions as necessary, as well as oral hygiene instruction. Sealants were applied to all permanent teeth that did not show signs of clinical decay; they were re-applied at each successive year in the program as indicated. Education in the classrooms was provided to the children enrolled in the school. Education and oral hygiene instruction were given to the teachers, the school nurse and the principal, as well as to interested parents.

Caregivers voluntarily brought their children to the clinic site in the school for this service. Consent to enlist their children into the school-based program was obtained from the children's parents verbally and in writing to the school. Teachers from each classroom accompanied the children to the designated clinic area.

A chart review for secondary data analysis was approved (study number S12-01754) by the New York University School of Medicine Institutional Review Board. The purpose of this data analysis was to determine the caries prevalence in the target group, treatment needs and the level to which those needs were met in this service project. Children who returned for at least a second visit in years two through five were analyzed to see if there was a change in their decay rate and if prevention occurred in each successive year.

Decay status at the first visit was compared to decay status at the second visit using a paired binomial test of discordant pairs; it was not appropriate to test the proportions as two independent samples because the subjects were seen more than once.

In order to conduct an analysis of the impact of repeated visits, a logistic mixed-effects model was fit to the data. The random effects component addressed the fact that there was correlation within subjects who were seen more than one time. The outcome measure was either general decay or decay in molars. Various time-varying predictors were considered as described below. Statistical models were compared using Akaike's Information Criterion (AIC), which is a model comparison tool that combines goodness of fit with a penalty for complexity; small values are preferred. The correct classification rate is the percent of visits (out of all patient encounters) that are correctly classified in terms of the presence of decay.

### Results

Data from dental encounters were recorded for each child receiving care during any of the five visits. In total, 172 children received care at least once during the visits. The age of children in 2007 ranged from 4 to 10 (average 7.0) years old. By 2011, the ages ranged from 8 to 12 (average 10.1) years. On average, there were 2.71 visits per child. There tends to be less decay



when the first visit is earlier in life, but results are not statistically significant.

#### **Effect of Treatment on Second Visit Decay**

The hypotheses are that the percent of children with decay in general and in molars in particular will decrease upon the second visit. Table 1 reports the results of an exact binomial test of symmetry of proportions in discordant pairs. In this test, children with at least two visits were classified by decay status on the first and second visits. If the decay is decreased by visiting the dentist, then one would expect fewer children without decay at time one to develop decay at time two than the number of children with decay at time one who did not have decay at time two. Of the 71 children with a first visit in 2007 and a second visit in 2008, five had a negative result (decay developed where it had not been before) and 21 had a positive result (decay in 2007 but no decay in 2008). The p-value for testing, where positive or negative results

are equally likely, is 0.0025, which is statistically significant. If all the children with a second visit are used, the p-value is 0.0090. Thus, there is a statistically significant reduction in the amount of decay in patients with two visits.

The comparison of decay in molars is not statistically significant. Six patients had decay in molars on the second visit when they did not have any at the first visit, whereas nine patients had no decay in molars at the second visit when they had decay at the first visit. A majority of the discordant pairs (9 out of 15; p-value two-sided 0.61), therefore, are favorable. These numbers do not change if the age at first visit is 7 or older, 6 or older, or unrestricted. If the analysis is restricted to those who had sealant applied to at least one molar at the first visit, the results also do not change: five out of seven who had different results on the two visits had positive outcomes at the second visit (2-sided p-value is 0.45). Thus, although results were favorable, the sample size was too small for findings to be statistically significant.

**TABLE 1.**  
**Number of Patients with Decay at First and Second Visit\***

First visit in 2007	Second Visit in 2008		First visit, any year	Second Visit, Any Year	
	No decay	Yes decay		No decay	Yes decay
No decay	32	5 (7%)	No decay	48	9 (8%)
Yes decay	21 (30%)	13	Yes decay	25 (23%)	26
P-value	0.0025				0.0090

\*Data are reported for patients with first visit in 2007 and second in 2008 and for all patients who had second visit. Statistical test is exact binomial test (two-sided) of symmetry using discordant pairs.

#### **The Impact of Repeated Visits**

In order to conduct an analysis of the impact of repeat visits, a logistic, mixed-effects model was fit to the data. The outcome measure is either general decay or decay in molars. Various time-varying predictors were considered. They are:

1. Was there a previous visit? Yes or no.
2. Number of previous visits.
3. Was there a previous sealant on a molar? Yes or no.
4. Number of previous sealants on molars.
5. Age.

Decay was indicated by a report of decay, an extraction or filling with glass ionomer cement (GIC). The number of sealants was recorded as the number of visits on which sealants were



placed; if needed, sealants were replaced after the first visit in which a sealant was placed. The previous sealant is 0 if there was no sealant at or before a given visit; it is 1 if a sealant was placed before the current visit. Forty-six children never had a sealant placed either because of existing decay or because they did not have permanent molars. Sealants were placed 1, 2, 3, 4 and 5 times, respectively, on 52, 37, 22, 14 and 1 children/child.

Table 2 reports results of fitting 12 statistical models. Models in the table are indexed by row (1, 2 or 3) and column (1, 2, 3 or 4) in the table. Models in Row 1 use one predictor out of the first four listed above. In all cases, these variables are highly statistically significant. Ever having a previous visit, the number of previous visits, ever having a previous seal and the number of previous sealants are all predictive of less decay. Interpreting the exponent of the coefficients as odds ratios, the odds ratio for having decay is 0.39, 0.70, 0.33 and 0.46 for children having a previous visit, having one previous visit, having a previous seal and having one previous seal, respectively. These odds ratios are statistically significantly less than one. In the table, p-values for coefficients other than the intercept are in bold if they are less than 0.05.

Models in Row 2 add age to the previous predictors. The four previous variables remain statistically significant, with increased effect sizes in these models. Age is not a significant predictor when the other predictor is ever having a previous visit or ever having a seal. Age is near the 0.05 significance level when the other variable is the number of previous visits or the number of previous sealants. The positive coefficients on age suggest that older children are more likely to have decay in their teeth.

Models in Row 3 include two of the previous predictors plus age. The four combinations include one from ever having a previous visit and number of previous visits and one from ever having

a previous seal and number of previous sealants. All coefficients are negative, suggesting that these are predictive of fewer instances of decay, but not all coefficients are statistically significant in these combinations. This is likely due to sample size and the fact that these variables are positively associated with one another. In every model, at least one predictor is highly statistically significant. Age is nearly or barely statistically significant in all models; the positive sign as before suggests that older children are more likely to have decay in their teeth.

The AIC criterion value suggests a model with number of sealants on molars and age (Row 2, column 4) is the preferred model due to it having the lowest AIC value. A model with age alone as a predictor in the logistic mixed-effects model had an AIC value of 540 and a nonsignificant effect of age (coefficient -0.09, p-value of 0.319); it is not reported in the table. The correct classification rate (out of 464 patient encounters) is between 85% and 87% for all models in Table 2.

Models were fit with decay in molars as the outcome. Results are given in Table 3. Models using only a single predictor were not statistically significant, except when the single predictor was age. Of the 397 times there was no decay in molars, no decay was predicted 392 times (99%). Of the 66 times there was decay in molars, decay was predicted 44 times (67%). Overall, the correct classification rate is 94%. Adjusting for age, having sealants ever placed on molars and the number of molar sealants are highly statistically significant predictors of not having decay in molars. Adding additional variables did not improve the AIC value or otherwise improve models.

## Discussion

Exact binomial tests of discordant pairs show statistically significant

**TABLE 2.**  
**Logistic Regression Coefficients in Twelve Logistic Regression Mixed-effects Models to Predict Decay\***

	Column 1		Column 2		Column 3		Column 4	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
<b>Row 1</b>								
Intercept	-0.47	0.039	-0.27	0.378	-0.46	0.023	-0.03	0.900
Previous visit, yes or no (0-1)	-0.93	<b>&lt;0.001</b>						
Visit number (1-5)			-0.35	<b>0.002</b>				
Ever seal molars (0-1)					-1.12	<b>&lt;0.001</b>		
Seal number (0-5)							-0.77	<b>&lt;0.001</b>
AIC	545		548		541		533	
% correct classify	0.87		0.86		0.86		0.86	
<b>Row 2</b>								
Intercept	-1.44	0.081	-1.96	0.025	-1.73	0.029	-1.38	0.068
Previous visit, yes or no (0-1)	-1.08	<b>&lt;0.001</b>						
Visit number (1-5)			-0.57	<b>&lt;0.001</b>				
Ever seal molars (0-1)					-1.35	<b>&lt;0.001</b>		
Seal number (0-5)							-0.91	<b>&lt;0.001</b>
Age	0.12	0.245	0.25	<b>0.045</b>	0.16	0.099	0.18	0.056
AIC	531		530		525		<b>514; best model</b>	
% correct classify	0.87		0.86		0.86		0.86	
<b>Row 3</b>								
Intercept	-1.77	0.027	-1.65	0.040	-2.11	0.012	-1.42	0.091
Previous visit, yes or no (0-1)	-0.14	0.75	-0.35	0.304				
Visit number (1-5)					-0.24	0.200	-0.02	0.920
Ever seal molars (0-1)	-1.25	<b>0.007</b>			-1.06	<b>0.007</b>		
Seal number (0-5)			-0.83	<b>&lt;0.001</b>			-0.90	<b>&lt;0.001</b>
Age	0.17	0.095	0.22	<b>0.031</b>	0.25	<b>0.036</b>	0.19	0.111
AIC	527		516		526		517	
% correct classify	0.86		0.85		0.86		0.86	

\*Models are indexed by row (1, 2 or 3 predictor variables) and column (1, 2, 3 or 4). AIC criterion value suggests model with number of sealants on molars and age (row 2, column 4) is preferred. At least one co-efficient in each model is statistically significantly different from zero at 0.01 level. P-values for coefficients other than intercept are in bold if they are less than 0.05.

improvement of decay status from a first to a second visit. In linear mixed-effects models with time-varying covariates, ever having a previous visit, the number of previous visits, ever having a previous seal and the number of previous sealants are all predictive of less decay. The four previous variables remain statistically significant with increased effect sizes in models with age as a predictor. In linear, mixed-effects models, adjusting for age, the predictors indicating that sealants were ever placed on molars and the number of sealants on molars are highly statistically significant predictors of not having molar caries.

A limitation of this study is that it was performed in one school in one population. Some children were lost to follow-up,

possibly because they moved or were simply not at school on subsequent visits. No variables on household or family member characteristics and environment out of school are available. This was not a randomized comparison; all children available and with parental permission were treated. There is no systematic information on dental care outside of the visits (except for a few noted fillings). This study is short term and does not consider the long-term dental health of the subjects. More than one person evaluated each child, and all work was checked by a faculty member. But there likely was some variability by provider in diagnosing caries and in sealant proficiency.

**TABLE 3.**  
**Logistic Regression Coefficients in Logistic Regression Mixed-effects Models to Predict Decay in Molars\***

	Coef.	P-value	Coef.	P-value	Coef.	P-value
Intercept	-12.19	<0.001	-14.53	<0.001	-13.77	<0.001
Ever seal molars (0-1)			-2.44	<b>0.007</b>		
Seal number (0-5)					-1.23	<b>0.016</b>
Age	0.54	<b>0.006</b>	0.95	<b>&lt;0.001</b>	0.94	<b>&lt;0.001</b>
AIC	293		284		286	
% correct classify	94%		95%		96%	

\*At least one coefficient in each model is statistically significantly different from zero at 0.01 level. P-values for coefficients other than intercept are in bold if they are less than 0.05.

Additional positive benefits of the dental outreach can be noted. Educational outcomes were also seen in the teachers and school nurses. They now require the children to brush their teeth after the school lunch or snack time. This exercise did not occur before this study began. Over 100 NYU, Michigan State and Columbia University dental students rotated through the project. This experience was life changing, according to many of the participating students. Involvement in an outreach like this will promote continued service and care for children who are less fortunate with respect to economics and healthcare availability in the United States and abroad.

### Conclusions

The statistical evidence strongly indicates the positive benefit of dental visits and of placing sealants on permanent molars in a primary school population that has poor access to regular dental care. ✍

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### REFERENCES

- Larsen CD, Daronch M, Moursi AM. Topical fluoride therapy is a safe and effective method for reducing the risk of caries among children of all ages. *Dimension of Dental Hygiene* June 2012;10(6):19-22.
- Cirino SM, Scantlebury S. Dental caries in developing countries: preventive and restorative approaches to treatment. *New York State Dental Journal*. Feb 1998;64:32-39.
- Baez RJ, Marthaler TM, Baez MX, Warpeha RA. Urinary fluoride levels in Jamaican children in 2008, after 21 years of salt fluoridation. *Schweiz Monatsschr Zahnmed* 2010; 120(1):21-8.
- Liu BY, Lo ECM, Chu CH, Lin HC. Randomized trial on fluorides and sealants for fissure caries prevention. *Journal of Dental Research* 2012;91(8):753-758.
- Wennhall I, Mattson L, Schroder U, Twetman S. Outcome of an oral health outreach programme for preschool children in a low socioeconomic multicultural area. *International Journal of Paediatric Dentistry* March 2008;18(2):84-90.
- Memarpour M, Shafiei F, Shokouh P, Shaddel M. Evaluation of a school-based pit and fissure sealant programme in Iranian children. *Oral Health and Preventive Dentistry* 2011; 9(4):381-386.
- IOM (Institute of Medicine) and NRC (National Research Council). 2011. Improving access to oral health care for vulnerable and underserved populations. Washington, DC: The National Academies Press.

- Bailit H, D'Adamo J. State case studies: improving access to dental care for the underserved. *Journal of Public Health Dentistry* 2012;72(3):221-234.
- Siegel MD, Detty AMR. Do school-based dental sealant programs reach higher risk children? *Journal of Public Health Dentistry* 2010;70(3):181-187.
- Bhuridej P, Kuthy RA, Flach SD, Heller KE, Dawson DV, Kanellis MJ, Damiano PC. Four-year cost-utility analyses of sealed and nonsealed first permanent molars in Iowa Medicaid-enrolled children. *Journal of Public Health Dentistry* 2007;67(4):191-198.
- Griffin SO, Oong E, Kohn W, Vidakovic B, Gooch BF, Bader J, Clarkson J, Fontana MR, Meyer DM, Rozier RG, Weintraub JA, Zero DT. The effectiveness of sealants in managing caries lesions. *Journal of Dental Research* 2008; 87(2):169-174.
- Ahovuo-Saloranta A, Hiiri A, Nordblad A, Makela M, Worthington HV. Pit and fissure sealants for preventing dental decay in the permanent teeth of children and adolescents. (Cochrane Review) *The Cochrane Library*; Issue 2, 2009.
- Lalumandier JA, Molkenin KF. Establishing, funding, and sustaining a university outreach program in oral health. *Health Affairs* 2004; 23(6):250-254.
- Francis R, Mascarenhas AK, Soparkar P, Al-Mutawaa S. Retention and effectiveness of fissure sealants in Kuwaiti school children. *Community Dental Health* December 2008; 25(4): 211-215.
- Borges BCD, De Souza Bezerra Araujo RF, Dantas RF, De Araujo Lucena A, De Assuncao Pinheiro IV. Efficacy of a non-drilling approach to manage non-cavitated dentin occlusal caries in primary molars: a 12-month randomized controlled clinical trial. *International Journal of Paediatric Dentistry* 2012; 22:44-51.
- Hawkins R, Locker D, Noble J, Kay EJ. Prevention. Part 7: Professionally applied topical fluorides for caries prevention. *British Dental Journal* 2003;195(6):313-317.
- Lam A, Chu CH. Caries management with fluoride varnish of children in U.S. *New York State Dental Journal* June 2011:28-42.

# Successful Conservative Treatment of Dentigerous Cyst Following Intrusion of Lower Primary Incisors

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## ABSTRACT

**This paper reports on the development of a dentigerous cyst associated with a lower permanent incisor following intrusion of two lower primary incisors. The small root remnant of one of the traumatized primary incisors was associated with granulation tissue, while the second incisor was discolored and suspected of being non-vital. The associated permanent incisor and other adjacent incisors were apically and laterally dislocated from their natural site of eruption. The conservative treatment included extraction of the involved primary discolored incisor, as well as the root remnant, followed by removal of the granulation tissue. After 18 months of follow-up, the permanent incisors were erupting in normal position, without pathological signs of the dentigerous cyst.**

**Following severe traumatic injury to a primary tooth, periodic radiographic follow-up, until eruption of the correspondent permanent tooth, is recommended.**

Traumatic injuries to the primary incisor during the developmental stages of the corresponding permanent tooth may interfere with its future growth.<sup>1-2</sup> The extent of the disturbances increases after severe traumatic injury, usually intrusion or avulsion. A rare consequence of traumatic injury to a primary tooth is development of a dentigerous cyst in the corresponding permanent tooth.<sup>3</sup> There have been only five papers with eight case reports of dentigerous cysts associated with previous traumatic injury to the primary dentition published in the English literature; all of these cysts were located in the maxillary upper incisor region.<sup>4-8</sup>

The etiology of dentigerous cyst remains unclear, and several theories have been proposed to explain its origin.<sup>9,12-15</sup> One hypothesis suggests that the inflammation of periapical tissue originating from a primary tooth with necrotic pulp might stimulate the accumulation of fluid between the reduced enamel epithelium and the crown of the permanent tooth germ.

Dentigerous cysts occasionally become extensive, since lesions are asymptomatic even when they reach considerable size. Therefore, the treatment is difficult, as the associated teeth are often impacted and displaced a substantial distance.<sup>9-11</sup> Notwithstanding, in case of infection, dentigerous cysts might become symptomatic.

The classic treatment employed for elimination of dentigerous cyst includes decompression, enucleation and extraction of



**Figure 1.** Panoramic view of patient at six years and five months showing missing lower right lateral primary incisor. Lower right central permanent incisor is displaced apically with delayed root development and associated with dentigerous cyst. Adjacent permanent lower incisors are displaced laterally with delayed root development.



**Figure 2.** Panoramic view of patient three months following extraction of primary lower right central and lateral incisors. Permanent lower right central incisor is erupting. Adjacent incisors moved medially to original location. Significant decrease in size and radiolucency of dentigerous cyst is noted. Partial arrest of root development is suspected.



**Figure 3.** Clinical view nine months following extraction of primary lower right central and lateral incisors. Gingiva is healthy. Permanent lower left incisor erupted to oral cavity, and adjacent permanent incisors are almost erupting.



**Figure 4.** Panoramic view nine months following extraction of primary lower right central and lateral incisors. Complete healing of dentigerous cyst. Adjacent incisors are erupting to original location.

the tooth or teeth embedded in the cyst.<sup>9,10,16-24</sup> However, the criteria for selecting these treatment modalities are not clearly defined.<sup>16</sup> A more conservative management is cyst marsupialization with careful follow-up, waiting for the spontaneous eruption of the unerupted/impacted tooth. This modality has been performed with successful outcomes.<sup>10,16,19-20</sup>

Considering the fact that children have a much greater and quicker capacity for regeneration of bone than adults, and that teeth with open apices have a greater potential for eruption, large dentigerous cysts in children might be treated differently from those in adults. Conservative treatment with tooth preservation may be preferred in this age group.<sup>15,25-26</sup>

### Case Report

A six and one-half-year-old girl was referred to our dental clinic for consultation due to delayed eruption of her mandibular incisors. Medical history revealed that at 18 months, the girl underwent intrusion of her lower right central and lateral primary incisors, which re-erupted several months later with gray crown discoloration. Six months later, the crown of the lower right incisor was exfoliated. Clinical evaluation revealed granulation tissue associated with the root remnant of the lower right incisor and distal inclination of the discolored right central incisor, which was also slightly mobile. A slight

loss of space and no eruption of any of the permanent incisors were noted.

The panoramic radiograph (Figure 1) revealed a missing lower right lateral primary incisor. The lower right central permanent incisor was displaced apically with delayed root development and associated dentigerous cyst. The permanent lower right lateral and left central and lateral incisors were displaced laterally with delayed root development. The conservative treatment included extraction of the root remnant, curettage of the granulation tissue associated with it and extraction of the discolored lower right central primary incisor.

The treatment was performed after administration of local anesthesia under nitrous oxide analgesia. Clinical examination three months later revealed healthy gingiva with an erupting left central incisor. Panoramic examination (Figure 2) revealed that the right central incisor was erupting, and the adjacent incisors moved medially to their original location. A significant decrease in the size and radiolucency of the dentigerous cyst was noted. Partial arrest of root development was suspected.

Clinical examination six months later revealed healthy gingiva with the erupted left central incisor (Figure 3). The adjacent incisors were also erupting. The panoramic view (Figure 4) showed complete healing of the dentigerous cyst and the adjacent incisors erupting into their proper positions.

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## Discussion

This case describes a rare complication of intrusion of lower primary incisors and emphasizes the effectiveness of the conservative treatment option, followed by careful follow-up until eruption of the corresponding permanent teeth.

A dentigerous cyst is defined as one that encloses the crown of an un-erupted tooth and is attached at the cemento-enamel junction.<sup>27</sup> Histological examination usually shows a thin fibrous cyst wall lined by two to three layers of flat or cuboidal epithelial cells. Inflammatory cell infiltration of the cyst wall is common, and localized proliferation of the epithelial lining may occur in response. In such cases, an inflamed dentigerous cyst cannot be differentiated histologically from an inflammatory dental cyst.

Dentigerous cysts most commonly occur in the second and third decades of life, although they can also be found in children and adolescents.<sup>28</sup> These cysts account for more than 24% of jaw cysts. However, the incidence rate of dentigerous cysts involving the permanent central incisors is just 1.5%. Impaction of permanent incisors due to a dentigerous cyst associated with primary tooth intrusion is even more infrequent.

In the case presented here, inflammation around the apex of the traumatized primary incisors may have induced changes in the previously normal follicular epithelium of the successor

tooth, leading to epithelial proliferation, cystic transformation and impaction of the associated permanent incisor.<sup>29</sup>

Management options for such teeth include extraction of the primary tooth and further observation until the permanent incisors erupt, surgical extraction of the impacted tooth followed by implant placement, surgical repositioning and orthodontic correction.<sup>30</sup> Gondim et al. reported a case of a dentigerous cyst associated with the germ of a permanent maxillary central incisor that developed secondary to trauma to the predecessor primary incisor. The therapeutic approach included endodontic treatment of the primary tooth and marsupialization of the lesion.

After 36 months of follow-up, the permanent incisor presented with normal physiologic conditions, absence of dental anomalies, and it had erupted in its correct position in the oral cavity.<sup>8</sup> The researchers concluded that with proper case selection, marsupialization might be a good treatment option for conservative management of dentigerous cysts.

Children usually present with rapid wound healing and high tissue regenerative capacities. Therefore, as can be seen from this report, timely recognition and extraction of the primary tooth, followed by the observation period until the impacted permanent incisor erupts in the oral cavity, might be preferred over more aggressive treatment modalities. However, careful follow-up is a

major requirement in those cases. And if impacted permanent incisors fail to erupt, or the cyst fails to disappear, further intervention is warranted.

It is also noteworthy that when patients with injured primary teeth are treated, it is essential that parents be advised of the need for prolonged professional supervision until the eruption of the corresponding permanent tooth. Periodic evaluation should include radiographs at appropriate intervals to detect pathologic alterations, such as internal or external root resorption, pulp space calcification, periodontal ligament space changes, and alterations in surrounding alveolar bone, as well as to confirm undisturbed development of the underlying permanent teeth. Sometimes parental concerns regarding radiation safety might influence proper diagnostic decisions for the dentist.

Trauma to the deciduous teeth should not be overlooked, since it can result in development of pathology that could indirectly affect the permanent successors, as seen in this case. Hence, periodic visits to the dentist enable early detection, diagnosis and treatment and, as consequence, avoid morbidity. //

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## REFERENCES

1. Brin I, Fuks A, Ben-Bassat Y, Zilberman Y. Trauma to the primary incisors and its effect on the permanent successors. *Pediatr Dent* 1984;6:78-82.
2. Andreasen JO, Flores MY. Injuries to developing teeth. In: Andreasen JO, Andreasen FM, Andersson L, editors. *Textbook and Color Atlas of Traumatic Injuries to the Teeth*. Blackwell Publishing: Oxford, UK, 4th Ed. 2007, p. 542-76.
3. Andreasen JO, Flores MY. Injuries to developing teeth. In: Andreasen JO, Andreasen FM, Andersson L, editors. *Textbook and Color Atlas of Traumatic Injuries to the Teeth*. Blackwell Publishing: Oxford, UK, 4th Ed. 2007, p. 562-63, 569.
4. Naclerio H, Simoes WA, Zindel D, Chilvarquer I, Aparecida TA. Dentigerous cyst associated with an upper permanent central incisor: case report and literature review. *J Clin Pediatr Dent* 2002; 26 (2):187-92.
5. Killian CM, Leventhal PH, Tamaroff JL. Dentigerous cyst associated with trauma to a primary incisor: a case report. *Quintessence Int*. 1992;23(10):683-6.
6. Seddon RP, Fung DE, Barnard KM, Smith PB. Dentigerous cysts involving permanent incisors: four case reports. *Int J Paediatr Dent* 1992;2(2):105-11.
7. Bharath KP, Revathy V, Poornima S, Subba Reddy VV. Dentigerous cyst in an uncommon site: a rare entity. *J Indian Soc Pedod Prev Dent*. 2011;29 (6 Suppl 2):S99-103.
8. Gondim JO, Neto JJ, Nogueira RL, Giro EM. Conservative management of a dentigerous cyst secondary to primary tooth trauma. *Dent Traumatol* 2008;24(6):676-9.
9. Neville BW, Damm DD, Allen CM, Bouquet JE. Odontogenic cysts and tumors. In: Neville BW, editor. *Oral and Maxillofacial Pathology*, 2nd Ed. Philadelphia, PA: WB Saunders. 2002, p. 589-642.
10. Martinez-Pe´rez D, Varela-Morales M. Conservative treatment of dentigerous cysts in children: a report of 4 cases. *J Oral Maxillofac Surg* 2001;59:331-4.
11. Ertas U, Yavuz S. Interesting eruption of 4 teeth associated with a large dentigerous cyst in mandible by only marsupialization. *J Oral Maxillofac Surg* 2003;61:728-30.
12. Hyomoto M, Kawakami M, Inoue M, Kirita T. Clinical conditions for eruption of maxillary canines and mandibular premolars associated with dentigerous cysts. *Am J Orthod Dentofacial Orthop* 2003;124:515-20.
13. Aziz AS, Pulse C, Dourmas MA, Roser SM. Inferior alveolar nerve paresthesia associated with a mandibular dentigerous cyst. *J Oral Maxillofac Surg* 2002;60: 457-9.
14. Koselj V, Sotosek B. Inflammatory dentigerous cysts of children treated by tooth extraction and decompression – report of four cases. *Br Dent J* 1999;187:587-90.
15. Benn A, Altini M. Dentigerous cysts of inflammatory origin: a clinicopathologic study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1996;81:203-9.
16. Motamedi MH, Talesh KT. Management of extensive dentigerous cysts. *Br Dent J* 2005 Feb 26;198(4):203-6.
17. Assael I A. Surgical management of odontogenic cysts and tumors. In: Peterson LJ, Indresano T A, Marciani R D, Roser S M. *Principles of Oral and Maxillofacial Surgery*. Philadelphia: JB Lippincott. 1992(2): pp 685-8.
18. Regezi J A. Cyst and cystlike lesions. In: Regezi J A, Sciubba J, Pogrel M A. *Atlas of Oral and Maxillofacial Pathology*. Philadelphia: WB Saunders. 2000, pp 88.
19. Dammer R, Niederdelmann H, Dammer P, Nuebler-Moritz M. Conservative or radical treatment of keratocysts: a retrospective view. *Br J Oral Maxillofac Surg* 1997;35(1):46-8.
20. Aguiló L, Gandía J L. Dentigerous cyst of mandibular second premolar in a five year-old girl, related to a non vital primary molar removed one year earlier: a case report. *J Clin Pediatr Dent* 1998;22:155-8.
21. Sain D R, Hollis W A, Togrye A R. Correction of a superiorly displaced canine due to a large dentigerous cyst. *Am J Dentofac Orthop* 1992; 102: 270-6.
22. Clauser C, Zuccati G, Barone R, Villano A. Simplified surgical-orthodontic treatment of a dentigerous cyst. *J Clin Orthod* 1994; 28:103-6.
23. Ziccardi V B, Eggleston T I, Schneider R E. Using a fenestration technique to treat a large dentigerous cyst. *J Am Dent Assoc* 1997;128: 201-5.
24. Takagi S, Koyama S. Guided eruption of an impacted second premolar associated with a dentigerous cyst in the maxillary sinus of a 6-year-old child. *J Oral Maxillofac Surg* 1998;56:237-9.
25. Alkhatib A, Manton DJ. Case report: preservation of teeth involved with an odontogenic cyst. *Eur Arch Paediatr Dent* 2010;11(3):146-8.
26. Kirtaniya BC, Sachdev V, Singla A, Sharma AK. Marsupialization: a conservative approach for treating dentigerous cyst in children in the mixed dentition. *J Indian Soc Pedod Prev Dent* 2010;28(3):203-8.
27. Shear M. Dentigerous (follicular) cyst. In: *Cysts of the Oral Region*, 2nd Ed. Bristol: Wright PSG. 1983, 56-75.
28. Kalaskar RR, Tikku A, Damle SG. Dentigerous cyst of anterior maxilla in a young child: a case report. *J Indian Soc Pedod Prev Dent* 2007;25:187-90.
29. Harma D, Garg S, Singh G, Swami S. Trauma-induced dentigerous cyst involving an inverted impacted mesiodens: case report. *Dent Traumatol* 2010; 26 (3): 289-91.
30. Kalaskar RR, Kalaskar AR. Multidisciplinary management of impacted central incisors due to supernumerary teeth and an associated dentigerous cyst. *Contemp Clin Dent* 2011;2(1):53-8.

# Fractured Endodontic Instrument: A Clinical Dilemma

## Retrieve, Bypass or Entomb?

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### ABSTRACT

**A common clinical complication of root canal treatment is fracture of an endodontic file. The risk of treatment failure because of incomplete cleaning and shaping encourages the dentist to retrieve the fractured part. Several techniques have been offered to remove the fractured file, yet those techniques sacrifice sound dentin, which may lead to increased risk for perforations and root fractures. The aim of this article is to describe a clinical approach to accessing fractured files, depending on their location in the canal and stage of cleaning and shaping. This prudent approach may decrease complications from unnecessary dentin removal, while respecting the biological aspects of cleaning the canals.**

The fracture of endodontic instruments during root canal treatment is a complication every endodontist may have to deal with. The reported frequency rate for fractured instruments varies from 1% to 6% of cases.<sup>1</sup> Therefore, the prudent clinician should take all means necessary to prevent fracture of an endodontic instrument during root canal treatment.

The NiTi endodontic instrument manufacturers market the myth that increased flexibility make their files less prone to fracture.<sup>2</sup> However, endodontic practice worldwide has, unfortunately, disproved such a bold statement. The incidence of NiTi instrument fracture is about 5% even among highly skilled operators.<sup>3</sup> It has also been demonstrated that the torsional force necessary to cause fracture is similar for both NiTi and SS files—and in both clockwise and counterclockwise rotation.<sup>4</sup>

Stainless steel instrument fracture can be prevented mostly by identifying metal fatigue signs and discarding the instruments,<sup>5</sup> however, NiTi instrument separations can happen without any sign of fatigue.<sup>6-8</sup> Even the single use of rotary NiTi instruments doesn't prevent the chance of fracture entirely.<sup>9</sup>

Common reasons for fracture are flexural or torsional fatigue and metallurgic defects.<sup>7,9</sup> Haikel et al. have shown that the radius of curvature was the most significant factor in determining the fatigue resistance of the files.<sup>10</sup> The taper of files was also found to be significant in determining fracture time. As diameter increased, fracture time decreased.<sup>11</sup>

With the increasing popularity of new instruments, systems and surgical microscopes, clinicians are more inclined to attempt to remove retained fractured instruments. Even using a dental operating microscope has limitations. The visual reach of the microscope is limited to the straighter portion of the root canal

## The fracture of endodontic instruments during root canal treatment is a complication every endodontist may have to deal with.

system.<sup>12</sup> However, such clinical decisions must be based on biological and biomechanical considerations, not on manufacturers marketing new, untested products.

From a biological point of view, the most common cause of periapical lesions is intraradicular infection.<sup>11</sup> A broken file itself does not induce inflammation. We often see teeth with a fractured instrument inside canals that were treated long ago and have no clinical or radiologic signs of periapical inflammation (Figure 1). The impact of instrument fracture on the outcome of endodontic treatment depends mainly on the existence of an infected root canal and the stage of cleaning and shaping when the instrument fracture occurred.<sup>13</sup>

From a biomechanical point of view, direct access to the fractured instrument has been advised. This can be achieved by means of a modified Gates Glidden bur, use of ultrasonic equipment and the additional use of special grip instruments, such as IRS, Massermann Kit, STN and others.<sup>14</sup> The consequence of these procedures is the loss of remaining sound dentin,<sup>15</sup> the amount of which is directly proportional to the strength of an endodontically treated tooth, and the possibility of perforation<sup>16</sup> and predisposition to vertical root fracture.<sup>17</sup> It was demonstrated that vertical root fracture might account for up to 11% of endodontic failure.<sup>18</sup> Thus, before sacrificing dentin while trying to remove the separated instrument, all treatment considerations should be taken into account (Figures 2a, b).<sup>16</sup> Bypassing the fractured instrument fragment may permit proper instrumentation of the remaining apical portion of the canal to solve the problem of infection without sacrificing healthy dentin.<sup>19</sup>

### Method

We created the following clinical algorithm for different situations with broken instruments.

#### Vital Pulp

##### a. Instrument fractured in apical part of canal

Removal of a fractured file fragment should not be routinely attempted. There is no risk of residual infection with preservation of healthy dentin.<sup>20</sup> Agitation of NaOCl irrigation and obturation of the canal using the warm gutta-percha method is recommended.

##### b. Instrument fractured in middle part of canal

The best decision is to employ the bypass technique.

##### c. Instrument fractured in coronal part of canal

Removal of a fractured instrument should be attempted, with minimal dentin removal (Figures 3a, b, c).



**Figure 1.** Periapical radiograph of right first mandibular molar with separated file at mesial root. Patient had no symptoms.



**Figure 2a.** Periapical radiograph of right first maxillary molar with separated file at mesiobuccal root.



**Figure 2b.** After removing separated file, residual dentin thickness was significantly reduced.



**Figure 3a.** Periapical radiograph of right first maxillary molar with separated file at distobuccal root.



**Figure 3b.** Separated file was removed by using IRS device (Dentsply).



**Figure 3c.** Same tooth after separated file removal.

### Infected Case

In this instance, the possibility of a residual infection in the canal influences the situation.<sup>21</sup> Therefore, the action to be taken will be decided first by the risk of infection and second by the location of the broken instrument.

- a. **Instrument fractured after major cleaning and shaping—canal is prepared to at least #30**
  1. Apical + middle parts of canal: Removal of fractured file fragment should not be routinely attempted. Obturation up to the fragment is recommended.
  2. In coronal part of canal: Removal of fractured instrument should be attempted with minimal dentin removal.
- b. **Separation of instrument before significant instrumentation and irrigation have been performed**
  1. Since canal system is infected, extra effort should be taken to bypass the instrument.
  2. If bypass was unsuccessful and direct access to fragment is possible, retrieval procedure may be recommended.
  3. If bypass of fragment beyond curvature of the canal is unsuccessful, or attempts to remove fractured instrument have taken more than one hour and are ineffective, application of

Ca(OH)<sub>2</sub> for two to four weeks is recommended for disinfection. Follow-up is obligatory, and in case of post-treatment endodontic disease, apical surgery might be considered.

### Summary

The proposed clinical procedures are based upon the understanding of biological processes that are responsible for periapical lesions and tooth biomechanics. Our concern is that attempts to remove fractured instruments may risk the long-term success of the tooth by sacrificing sound dentin, which may lead to perforations and predispose the tooth to vertical root fracture. The clinician should consider micro-biological and mechanical aspects, combined with knowledge of clinical and skill limitations, before attempting any procedures. //

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### REFERENCES

1. Spili P, Parashos P, Messer H. The impact of instrument fracture on outcome of endodontic treatment. *J Endod* 2005;31:845-850.
2. Canalda-Sahli C, Brau-Aguadé E, Berástegui-Jimeno E. Torsional and bending properties of stainless steel and nickel titanium canal Master U and Flexogate instruments. *Endodent Traumatol* 1996;12:141-145.
3. Di Fiore PM, Genov KA, Komaroff E, Li Y, Lin L. Nickel-titanium rotary instrument fracture: a clinical practice assessment. *Int Endod J* 2006;39:700-708.
4. Rowan MB, Nicholls J, Steiner J. Torsional properties of stainless steel and nickel titanium Endodontic Files. *J Endod* 1996; 22:341-345.
5. Glickman GN, Dumsha TC. Problems in canal cleaning and shaping. In: Gutman L, Dumsha C, Lovdahl, Hovland E, editors. *Problem Solving in Endodontics*. 3rd Ed. St Louis (MO): C.V. Mosby; 1997. p. 91.
6. Alapati SB, Brantley WA, Svec TA, Powers JM, Nusstein JM, Daehn GS. SEM observations of nickel-titanium rotary endodontic instruments that fractured during clinical use. *J Endod* 2005;31:40-43.
7. Parashos P, Gordon I, Messer HH. Factors influencing defects of rotary nickel-titanium endodontic instruments after clinical use. *J Endod* 2004; 30:722-725.
8. Pruett JP, Clement D J, Carnes DL Jr. Cyclic fatigue testing of NiTi endodontic instruments. *J Endod* 1997;23:77-85.
9. Arens FC, Hoen MM, Steiman HR, Dietz GC, Jr. Evaluation of single-use rotary nickel-titanium instruments. *J Endod* 2003;29:664-666.
10. Haikel Y, Serfaty R, Bateman G, Senger G, Allemann C. Dynamic and cyclic fatigue of engine-driven rotary nickel-titanium endodontic instruments. *J Endod* 1999;25:434-440.
11. Kakehashi S, Stanley HR, Fitzgerald RJ. The effects of surgical exposures of dental pulps in germ-free and conventional laboratory rats. *Oral Surg Oral Med Oral Pathol* 1965;20:340-349.
12. Nevares G, Cunha RS, Zuolo ML, Bueno CES. (2012) Success rates for removing or bypassing fractured instruments: a prospective clinical study. *J Endod* 38, 442-444.
13. Fors UGH, Berg JO. Endodontic treatment of root canals obstructed by foreign objects. *Int Endod J* 1986;19:2-10.
14. Ruddle CJ. Micro-endodontic nonsurgical retreatment. *Dent Clin North Am* 1997; 41:429-454.
15. Sornkul E, Stannard JG. Strength of roots before and after endodontic treatment and restoration. *J Endod* 1992;18:440-443.
16. Souter NJ, Messer HH. Complications associated with fractured file removal using an ultrasonic technique. *J Endod* 2005;31: 450-452.
17. Lertchirakarn V, Palamara JEA, Messer HH. Patterns of vertical root fracture: factors affecting stress distribution in the root canal. *J Endod* 2003; 29:523-528.
18. Fuss Z, Lustig J, Tamse A. Prevalence of vertical root fractures in extracted endodontically treated teeth. *Int Endod J* 1999;32:283-286.
19. Suter B, Lussi A, Sequeira P. Probability of removing fractured instruments from root canals. *Int Endod J* 2005;38:112-123.
20. Friedman S, Abitbol S, Lawrence HP. Treatment outcome in endodontics: the Toronto study. Phase 1: initial treatment. *Endod* 2003;29:787-793.
21. Saunders JL, Eleazer PD, Zhang P, Michalek S. Effect of a separated instrument on bacterial penetration of obturated root canals. *J Endod* 2004;30:177-179.

# PAOO for Faster Function, Aesthetics and Harmony

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## ABSTRACT

**Periodontally accelerated osteogenic orthodontics (PAOO) is a clinical procedure that combines selective alveolar corticotomy, particulate bone grafting and the application of orthodontic forces. PAOO can play an important role in the comprehensive treatment of a patient's occlusal and esthetic needs. This technique has been shown to increase alveolar bone thickness, decrease treatment time and enhance post-treatment orthodontic stability. Contained in this review is a discussion of the different aspects of PAOO and an assessment of its role in comprehensive treatment planning for the orthodontic patient.**

Malpositioned teeth are responsible for esthetic and occlusal aberrations in many adults. Malocclusions can be caused by several factors, including the spread of advanced periodontal disease, dental migrations towards areas of tooth loss and tooth movement produced by traumatic occlusal problems. Traditional orthodontic movement is the result of periodontal ligament compression, which produces histologic and biomolecular modifications

of the periodontal tissues that activate the dynamics of crestal bone resorption and apposition. Thus, orthodontic movement is considered a “periodontal phenomenon” because all periodontal tissues are involved.<sup>1</sup> Over the last two decades, refinements of an attempt to engineer an “optimal response” of alveolar bone to applied “optimal force” has propelled both the periodontal and the orthodontic specialties directly into the field of surgical dentofacial orthopedics.<sup>2</sup>

The periodontally accelerated osteogenic orthodontics (PAOO) technique provides an increased net alveolar volume after orthodontic treatment. It is a combination of a selective decortication-facilitated orthodontic technique and alveolar augmentation. With this technique, one is no longer at the mercy of the preexisting alveolar volume, and teeth can be moved two- to three-times further in a third to a quarter of the time required for traditional orthodontic therapy. It can be used to treat moderate-to-severe malocclusions in both adolescents and adults, and can reduce the need for extractions. Except for severe Class III skeletal dysplasia, PAOO can replace some orthognathic surgery. And because of the low morbidity, patients 11 to 78 years old have been treated with marked biologic impunity.<sup>2</sup>

## Historical Review

Heinrich Köle's publication in 1959<sup>3</sup> set the stage for the subsequent evolution of refined decortication-facilitated orthodon-

tics. Köle believed that it was the continuity and thickness of the denser layer of cortical bone that offered the most resistance to tooth movement. He theorized that by disrupting the continuity of this cortical layer of bone, he was actually creating and moving segments of bone in which the teeth were embedded. The blocks of bone were outlined using vertical interradicular corticotomy cuts, both facially and lingually. These were joined 10 mm supra-apically with an osteotomy cut through the entire thickness of the alveolus. From Köle's work arose the term "bony block" to describe the suspected mode of movement following corticotomy surgery, a more morbid procedure than modern, refined modes of therapy.<sup>2</sup>

Gantes and coworkers in 1990 reported on corticotomy-facilitated orthodontics in five adult patients in whom space closing was attempted with merely orthodontic forces.<sup>4</sup> The mean treatment time for these patients was 14.8 months, with the distalization of the canines mostly completed in 7 months. The mean treatment time for the traditional orthodontic control group was 28.3 months.

The AOO/PAOO procedure was developed by Dr. Thomas and Dr. William Wilcko in 1995. This procedure is also known as Wilckodontics.

The interpretation of the rapid tooth movement attributable to bony block movement prevailed in the reported literature until 2001, when Wilcko and coworkers<sup>5</sup> reported that in a surface computed tomographic (CT) scan evaluation of selectively decorticated patients, it was discovered that the rapid tooth movement was not the result of bony block movement, but the result of a transient localized demineralization remineralization phenomenon in the bony alveolar housing consistent with the wound healing pattern of the regional acceleratory phenomenon (RAP), developed by Frost and Jee and described in the periodontal literature by Yaffe and coworkers.<sup>6</sup> Wilcko and coworkers have also demonstrated that it is not the design of the selective alveolar decortication that is responsible for the rapid tooth movement<sup>7</sup> but, rather, the degree of tissue metabolic perturbation.

### Indications

1. Dehiscences and fenestrations over prominent root surfaces. PAOO not only prevents formation of new fenestrations and dehiscences, it can also correct existing ones. This can be attributed to increased bone volume.
2. Anterior open bites and deviated midlines.

3. Crossbites and tooth size arch length discrepancies. Traditional orthodontics can satisfactorily address crowding up to 5 mm. This can be extended to 10 mm to 12 mm if PAOO technique is utilized.
4. Conservative alternative to orthognathic surgery. Except for severe Class III skeletal dysplasia, PAOO can replace orthognathic surgery and traditional decortication because of lower morbidity.
5. Where buccolingual width of alveolar ridge is less and extraction is contraindicated due to facial profile.
6. Moderate-to-severe malocclusions in both adolescents and adults.

### The Surgical Technique<sup>8</sup>

Periodontal accelerated osteogenic orthodontics (PAOO) is a clinical procedure that combines selective alveolar corticotomy, particulate bone grafting and the application of orthodontic forces. A corticotomy is defined as a surgical procedure whereby only the cortical bone is cut, perforated or mechanically altered. The medullary bone is not changed.

Careful coordination between the surgeon and orthodontist is required for successful outcomes. It is suggested that the surgeon and orthodontist be trained together in use of this technique to ensure a common basis of knowledge.

The surgical specialist must also evaluate the esthetic needs of the patient and incorporate these requirements into the surgical treatment

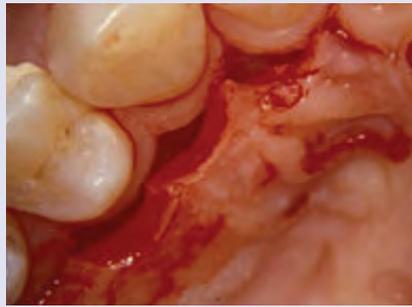
plan. For example, if a patient presents with gingival recession in an area requiring corticotomy, a subepithelial connective tissue graft can be placed in conjunction with the PAOO surgery. In some cases, anchorage must be established before the PAOO procedure is initiated. This is most commonly seen in Class II malocclusions requiring retraction.

The placement of orthodontic brackets and activation of the arch wires are typically done the week before the surgical aspect of PAOO is performed. However, bracketing can occur up to one to two weeks after surgery. If complex mucogingival procedures are combined with the PAOO surgery, the lack of fixed orthodontic appliances may enable easier flap manipulation and suturing. In all cases, initiation of orthodontic force should not be delayed more than two weeks after surgery. A longer delay will fail to take full advantage of the limited time in which the RAP is occurring.

The periodontally accelerated osteogenic orthodontics (PAOO) technique provides an increased net alveolar volume after orthodontic treatment. It is a combination of a selective decortication-facilitated orthodontic technique and alveolar augmentation.



**Figure 1.** Initial incision. Not carried through papilla.



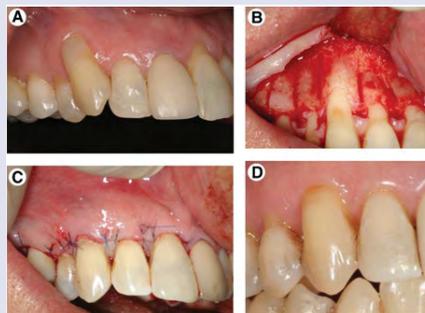
**Figure 2.** Palatal incision leaving collar of gingival tissue. Decreases likelihood of sloughing of interproximal tissue.



**Figure 3.** Decortication scheme.



**Figure 4.** Particulate bone graft layered over decorticated alveolar bone.



**Figure 5A.** Pretreatment view of patient undergoing PAOO procedure, presenting with severe gingival recession on canine.

**B.** Composite restoration removed and corticotomies performed.

**C.** Subepithelial connective tissue graft placed under coronally advanced flap.

**D.** Two-year postsurgical result.

### Flap Design

The objectives of the flap design are to:

1. Provide access to the alveolar bone wherein corticotomies are to be performed.
2. Provide for coverage of the particulate graft.
3. Maintain the height and volume of the interdental tissues.
4. Enhance the esthetic appearance of the gingival form where necessary.

The basic flap design is a combination of a full thickness flap in the most coronal aspect of the flap and a split-thickness dissection performed in the apical portions. The purpose of the split-thickness dissection is to provide mobility of the flap so that it can be sutured with minimal tension. Mesial and distal extension of the flap beyond the corticotomy areas is suggested to reduce the need for vertical releasing incisions. The initial incision is carried out on both surfaces of the alveolus. Preservation of the interdental gingival tissues is critical for a successful esthetic outcome (Figure 1).<sup>8</sup>

Retention of a palatal or lingual gingival collar of tissue, not reflected from the underlying alveolar bone, is frequently used to provide a collateral blood supply to the papillary tissue (Figure 2).<sup>8</sup>

### Decortication

The purpose of the decortication is to initiate the RAP response and not to create movable bone segments. By using a No. 1 or

No. 2 round bur in either a high-speed handpiece or dental implant drill, decortications are made in the alveolar bone.<sup>8</sup> Vertical corticotomy cuts are made between the roots using a diamond round bur (size 2), stopping just short of the alveolar crest (about 3 mm). These cuts are connected beyond the apices of the teeth (when possible) with scalloped horizontal cuts.<sup>9</sup> If the alveolar bone is of sufficient thickness, solitary perforations may be placed in the alveolar bone over the radicular surface (Figure 3). However, if this bone is estimated to be less than 1 mm to 2 mm in thickness, these perforations are omitted to ensure no damage occurs to the radicular surface. The corticotomies may also be achieved with a piezoelectric knife.<sup>8</sup>

### Particulate Grafting

Grafting is done in most areas that have undergone corticotomies (Figure 4). The volume of the graft material used is dictated by the direction and amount of tooth movement predicted, the pretreatment thickness of the alveolar bone and the need for labial support by the alveolar bone. The most commonly used materials are deproteinized bovine bone, autogenous bone, decalcified freeze-dried bone allograft, or a combination thereof. A typical volume of graft material used is 0.25 ml to 0.5 ml per tooth.<sup>8</sup> The use of platelet rich plasma or calcium sulfate has been reported to increase the stability of the graft material. If there is any recession in the teeth, it can be treated at the same time with connective tissue graft or acellular dermal matrix allograft<sup>9</sup> (Figure 5).<sup>8</sup>

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### Closure Techniques and Patient Management

Primary closure of the gingival flaps without excessive tension and graft containment are the therapeutic endpoints of suturing. The sutures that approximate the tissues at the midline are placed first to ensure the proper alignment of the papillae. The remaining interproximal sutures are placed next, followed by the closure of any vertical incisions. The sutures are usually left in place for one to two weeks.<sup>8</sup>

Antibiotics and pain medications are administered at the clinician's preference. However, long-term postoperative administration of nonsteroidal anti-inflammatory agents is discouraged, because they may theoretically interfere with the regional acceleratory process. The application of icepacks to the affected areas also is suggested to decrease the severity of any possible postoperative swelling or edema.<sup>8</sup>

Two weeks postsurgery, accelerated orthodontic treatment can be resumed. The intervals for orthodontic adjustments averaged two weeks, ranging from one to three weeks. During orthodontic treatment, the patient should be in three-month recall visits to the periodontist to assess oral hygiene and assure good periodontal health.<sup>9</sup>

### Discussion

PAOO can play an important role in the comprehensive treatment of a patient's occlusal and esthetic needs. This technique has been shown to increase alveolar bone thickness, decrease treatment time and enhance post-treatment orthodontic stability. PAOO is an extension of previously described techniques that surgically alter the alveolar bone to decrease treatment time. It differs from prior techniques by the additional step of alveolar bone grafting. It is this additional step that is believed to be responsible for the increased post-treatment alveolar bone width. Likewise, the additional alveolar bone width may be responsible for enhanced long-term orthodontic stability.<sup>8</sup>

It is suggested, based on modern scientific biological concepts and anatomical imaging innovations, that after the relatively thin alveolar housing over the labial and lingual root surfaces undergoes demineralization, the collagenous soft tissue matrix of the bone remains and, consequently, can be readily transported with the root surfaces through "bone matrix transportation." When retained in the desired position, the collagenous soft tissue matrix will remineralize with time.<sup>2</sup>

Selective alveolar decortication (SAD) facilitated orthodontics is a physiologically driven process. An uninterrupted vascular supply to the operated areas is critical in maintaining the vitality of the hard and soft tissues. "Mobilization" of any outlined single-tooth blocks of bone (luxation) is absolutely contraindicated and can lead to intrapulpal and intraosseous morbidity and will not increase the distance that the tooth can be moved.<sup>2</sup>

Sebaoun and coworkers<sup>10</sup> reported that selective alveolar decortication injury resulted in an overwhelming activating stimu-

lus for both the catabolic process (resorption response) and the anabolic process (formation response) in the periodontium. This bone modeling behavior peaked at three weeks after decortication surgery, at which time the catabolic response (osteoclastic count) and anabolic response (apposition width and rate) were three-fold higher.

Selective alveolar decortications result in a transient osteopenia and increased tissue turnover, the degree of which is directly commensurate with the intensity and proximity of the surgical physiologic insult.<sup>2</sup> This is a condition that favors tooth movement with reduced root resorption.

As concerns stability, Ferguson states, "PAOO has contributed greater stability of orthodontic clinical outcomes and less relapse." Summarizing, he says, "Immediate post-orthodontic treatment results following nonextraction therapy are statistically the same with or without PAOO. However, during retention, the clinical outcomes of PAOO patients improved and did not demonstrate relapse."<sup>2</sup>

### Advantages of PAOO<sup>9</sup>

- Reduced treatment time to one-third that of conventional orthodontics.
- Less root resorption due to decreased resistance of cortical bone.
- More bone support due to the addition of bone graft.
- History of relapse reported to be very low.
- Less need for extraoral appliances and headgear.
- Technique has its roots in orthodontic research and treatments.
- In the 10 years since PAOO was first applied, patient outcomes were good.
- Can be used to expedite the rate of movement of individual teeth or dental segments, i.e., canine and incisor retraction.

### Disadvantages of PAOO

- Extra surgical cost.
- Mildly invasive surgical procedure and, like all surgeries, has risks. Post-surgical crestal bone loss and recession may occur.
- Some pain and swelling is expected, as well as the possibility of infection.
- Not applicable to all cases. Proper case selection is necessary to attain good result. Maxillary and mandibular arch decrowding with normal skeletal relationship and incisor retraction are main indications.

### Conclusion

PAOO, an emerging technology, combines periodontal therapy with orthodontic therapy, enabling treatment time to be minimized. Favorably positioned teeth, plus an enhanced muco-gingival complex, facilitate ideal esthetic, restorative and reconstructive dental treatment.

It can be assumed that a decrease in the length of treatment would probably increase the likelihood that patients, especially adults, would elect to pursue orthodontic therapy when they would otherwise decline treatment. Conversely, the introduction of a surgical phase to the orthodontic therapy may prevent a patient from considering PAOO as a treatment option. Only after careful consultation and communication with an orthodontic therapist, periodontal therapist, and oral and maxillofacial surgeon will the patient be able to understand the advantages and disadvantages of treatment

From an esthetic perspective, the PAOO technique addresses not only tooth alignment, but also facial features. As such, it is truly *in vivo* tissue engineering. With a combination of both in-office periodontal surgery and orthodontic treatment, the esthetics of the entire lower face can be addressed.

PAOO is a relatively new procedure; hence, controlled clinical and histological studies are needed to understand the biology of tooth movement with this procedure, the effect on teeth and bone, post-retention stability, the volume of mature bone formation, and the status of the periodontium and roots after treatment.

PAOO serves as a reasonable and safe option for the growing demand for shortened treatment time of adult teeth movement in three dimensions. Further research is recommended for an in-

depth evaluation of the long-term stability claimed to be an advantage of this modality. //

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#### REFERENCES

1. Vercellotti T, Podesta A. Orthodontic microsurgery: a new surgically guided technique for dental movement. *International J Periodontics and Restorative Dentistry*. 2007;27(4): 325-331.
2. Wilcko MT, Wilcko WM, Bissada NF. An evidence-based analysis of periodontally accelerated orthodontic and osteogenic techniques: a synthesis of scientific perspectives. *Seminars in Orthodontics* 2008;14(4): 305-316.
3. Köle H. Surgical operations of the alveolar ridge to correct occlusal abnormalities. *Oral Surg Oral Med Oral Pathol* 1959;12:515-529.
4. Gantes B, Rathbun E, Anholm M. Effects on the periodontium following corticotomy-facilitated orthodontics: case reports. *J Periodontol* 1990;61:234-238.
5. Wilcko WM, Wilcko MT, Bouquot JE, et al. Rapid orthodontics with alveolar reshaping: two case reports of decrowding. *Int J Periodontics Restorative Dent* 2001; 21:9-19.
6. Yaffe A, Fine N, Binderman I. Regional accelerated phenomenon in the mandible following mucoperiosteal flap surgery. *J Periodontal* 1994;65:79-83.
7. Wilcko WM, Ferguson DJ, Bouquot JE. Rapid orthodontic decrowding with alveolar augmentation: case report. *World J Orthodont* 2003;4:197-505.
8. Murphy KG, Wilcko WM, Ferguson DJ. Periodontal accelerated osteogenic orthodontics: a description of the surgical technique. *J Oral Maxillofac Surg* 2009;67:2160-2166.
9. AlGhamdi AST. Corticotomy facilitated orthodontics: review of a technique. *The Saudi Dental Journal* 2010; 22: 1-5.
10. Sebaoun J-D, Ferguson DJ, Wilcko MT. Corticotomie. Alvéolaire et traitements orthodontiques rapides. *Orthod Fr* 2007;78:217-225.

# Antifungal Effects of Root Canal Irrigants and Medicaments

## An Update Review

Zahed Mohammadi, D.M.D., M.S.D.; Sousan Shalavi, D.M.D.

### ABSTRACT

**Fungi, especially *Candida albicans*, play an important role in persistent/secondary endodontic infections. There are several irrigants and medicaments in the field of endodontics. The purpose of this paper is to review the antifungal activity of sodium hypochlorite, chlorhexidine, MTAD, Tetraclean, EDTA, calcium hydroxide and MTA.**

Approximately 50,000 species of fungi are present in nature. Among these, more than 200 species cause diseases in vertebrates and human beings. Most of the pathogenic fungi fall into four groups as follows: *Ascomycetes*, *Basidiomycetes*, *Zygomycetes* and *Deuteromycetes*. The most frequently encountered species of opportunistic fungal pathogens are members of the genera *Candida* and *Aspergillus*, both belonging to the *Deuteromycetes* group.<sup>1</sup>

The *Candida* species can induce a wide spectrum of infections in humans, ranging from superficial disease to life-threatening disseminated mycoses.<sup>1</sup>

Fungi constitute a small part of the oral microbiota. The largest proportion of the fungal microbiota is made up of the *Candida* species. *Candida albicans* is the fungal species most commonly detected in the oral cavity of both healthy and medically compro-

mised individuals.<sup>2</sup> The incidence of *C. albicans* in the oral cavity has been reported to be 30% to 45% in healthy adults<sup>3,4</sup> and 95% in patients infected with human immunodeficiency virus.<sup>5</sup> Studies using culturing, molecular genetic and in situ electron microscopy methods have demonstrated that fungi are not common members of the microbiota associated with primary endodontic infections.<sup>1,2</sup> However, they seem to be more common in the root canals of root-filled teeth in which the treatment has failed.<sup>1,2</sup>

### Virulence Factors

*C. albicans* has several virulence factors. These factors include adaptability to a variety of environmental conditions, adhesion to a variety of surfaces, production of hydrolytic enzymes, morphologic transition, biofilm formation, and evasion and immunomodulation of the host defense.<sup>6</sup>

### Prevalence in Endodontic Infections

#### Primary Infections

Studies using culturing, molecular genetic methods and in situ electron microscopy have shown that fungi are not prevalent in primary endodontic infections. A study reported *Candida* species from 1 of 29 samples from necrotic pulps.<sup>7</sup> Another study using polymerase chain reaction (PCR) detected *C. albicans* in 5 of 24 root canal samples.<sup>8</sup> *Saccharomyces cerevisiae* was isolated from 1 of 26 root canals asso-

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ciated with asymptomatic periradicular lesions.<sup>9,10</sup> *C. tropicalis* was isolated from two, and *S. cerevisiae* was isolated from one of 27 patients with primary root canal infections. Using PCR, Siqueira et al.<sup>11</sup> detected fungi in one of 50 infected root canals. Sen et al.<sup>12</sup> found yeasts heavily invading the root canals of 4 of 10 extracted teeth associated with periradicular lesions.

#### **Persistent and Secondary Infections**

Fungi are common in the root canals of obturated teeth in which treatment has failed.<sup>1,2</sup> A study found fungi in two of nine surgical block biopsy specimens from refractory periradicular lesions.<sup>13</sup> In another study, fungi were found in 47 of 692 cases of persistent endodontic infections, either in pure culture or along with bacteria.<sup>14</sup> Sundqvist et al.<sup>15</sup> isolated *C. albicans* from 2 of 24 canals of teeth with failed endodontic treatment. Under similar conditions, Molander et al.<sup>16</sup> found *C. albicans* in 3 of 68 samples of root-filled teeth with periradicular lesions. Using the culture method, Pinheiro et al.<sup>17</sup> found *Candida* species in 2 of 51 patients. Using polymerase chain reaction, Siqueira and Rôças<sup>18</sup> detected *C. albicans* in 2 of 22 patients.

Taken together, all these reports lend support to the assertion that fungi can gain access to the root canals through contamina-

tion during endodontic therapy and can be involved in the etiology of recalcitrant periradicular lesions.

#### **Antifungal Effect of Root Canal Irrigants and Medicaments Sodium Hypochlorite**

Sodium hypochlorite is the most common root canal irrigation solution.<sup>19</sup> Coolidge<sup>20</sup> recommended NaOCl as an endodontic irrigant for the first time in 1919. NaOCl has a wide range of antimicrobial activity against both gram-positive and gram-negative bacteria, spores, fungi and viruses. Thus, sodium hypochlorite presents antimicrobial activity with action on bacterial essential enzymatic sites promoting irreversible inactivation originated by hydroxyl ions and chloramination action. Dissolution of organic tissue can be verified in the saponification reaction when sodium hypochlorite degrades fatty acids and lipids, resulting in soap and glycerol.<sup>19</sup>

Besides having excellent antimicrobial activity, NaOCl possesses exceptional tissue-dissolving ability. Dentin and contents of the root canal system decrease the antimicrobial activity of NaOCl significantly. It seems that heating NaOCl increases its antimicrobial and tissue-dissolving abilities. NaOCl exerts deteriorative effects on mechanical properties and chemical composition of dentin. Effects of NaOCl on the strength of bonding

systems are still controversial. In addition, NaOCl has excellent haemostatic activity.<sup>19</sup>

Studies have been conducted on the antifungal activity of NaOCl. According to Ferguson et al.,<sup>21</sup> NaOCl was very effective against *C. albicans*, having a minimum inhibitory concentration (MIC) of less than 10 µg/mL-1.

Sen et al.<sup>22</sup> evaluated the antifungal properties of 1% NaOCl and 5% NaOCl against *Candida albicans* using cylindrical dentin tubes and found that *C. albicans* was more resistant in the presence of the smear layer than in the absence of the smear layer. When the smear layer was absent, NaOCl started to display antifungal activity after 30 minutes. Waltimo et al.<sup>23</sup> evaluated the susceptibility of seven strains of *C. albicans* to NaOCl and found that both concentrations killed all yeast cells within 30 seconds. Ruff et al.<sup>24</sup> found that 6% NaOCl was equally effective and statistically significantly superior to BioPure MTAD and 17% EDTA in antifungal activity. Radcliffe et al.<sup>25</sup> demonstrated that four concentrations of NaOCl lowered CFU below the limit of detection after 10 seconds in the case of *C. albicans*. This finding was confirmed by Ayhan et al.<sup>26</sup>

Taken together, this may show that the antifungal activity of NaOCl is superior to other common irrigation solutions.

### Chlorhexidine

CHX is a synthetic cationic bisguanide that consists of two symmetric four-chlorophenyl rings and two bisguanide groups connected by a central hexamethylene chain.<sup>27</sup> CHX is a positively charged hydrophobic and lipophilic molecule that interacts with phospholipids and lipopolysaccharides on the cell membrane of bacteria and then enters the cell through some type of active or passive transport mechanism.<sup>27</sup> Its efficacy is due to the interaction of the positive charge of the molecule and the negatively charged phosphate groups on microbial cell walls, thereby altering the cells' osmotic equilibrium. This increases the permeability of the cell wall, which allows the CHX molecule to penetrate into the bacteria. CHX is a base, and is stable as a salt.<sup>27</sup>

At low concentration (0.2%), low molecular weight substances, specifically potassium and phosphorous, will leak out of the cell. However, at higher concentrations (2%), CHX is a bactericidal, as precipitation of the cytoplasmic contents occurs, which results in cell death.<sup>28</sup>

Sen et al.<sup>22</sup> assessed the antifungal activity of 0.12% CHX against *Candida albicans* in a human tooth model. They reported that *C. albicans* was more resistant to CHX when the smear layer was present than when it was absent. Ferguson et al.<sup>21</sup> showed that a minimum inhibitory concentration (MIC) of CHX to inhibit *C. albicans* was less than 0.63 µg/mL. According to Gomes et al.,<sup>29</sup> 2% CHX gel eliminated *C. albicans* after 15 seconds. Sena et al.<sup>30</sup> revealed that the contact time of CHX for negative cultures of *C. albicans* was in the range of 30 to 1,800 seconds. Waltimo et al.<sup>23</sup> evaluated the susceptibility of seven strains of *C. albicans* to 0.5 % CHX-acetate and showed that the complete killing of fungal cells occurred after five minutes.

Siqueira et al.<sup>31</sup> evaluated the effectiveness of CHX-zinc oxide in disinfecting root dentin in bovine teeth experimentally infected with *C. albicans* and found that the root canals were completely disinfected after one hour of exposure.

### EDTA

Ethylenediamine-tetraacetic acid was first introduced to endodontics by Nygaard-Ostby, who recommended the use of a 15% EDTA solution (pH 7.3) with the following composition: disodium salt of EDTA (17 g), aqua dest (100mL) and 5M sodium hydroxide (9.25 mL). EDTA has six potential sites (four carboxyl groups and two amino groups) available to bond with a metal such as calcium.<sup>32</sup> The structures of Ca-EDTA complexes, in which the calcium ion is effectively surrounded and isolated from the solvent, are highly stable. Due to its ability to form complexes with calcium ions, EDTA is commonly used to remove the smear layer in nonsurgical endodontic treatment.<sup>33</sup>

Sen et al.<sup>33</sup> evaluated the antifungal effect of EDTA on *Candida albicans* and compared it to that of various disinfectants and common antifungal agents using the agar diffusion test and found that EDTA was more effective than other tested agents. EDTA demonstrated the highest antifungal activity in comparison with routine antifungal drugs and all other solutions. Ates et al.<sup>34</sup> assessed antifungal effects of calcium-chelating or -binding agents on *C. albicans* and some conventional antifungal agents, including EDTA, ethyleneglycol-tetraacetic acid (EGTA), sodium fluoride, titanium tetrafluoride, nystatin and ketoconazole. The findings showed that except for ketoconazole, EDTA had the highest antifungal and fungicidal activity. The efficacy of EDTA on *C. albicans* was confirmed by Turk et al. in another study. On the other hand, Ruff et al.<sup>24</sup> showed that the efficacy of EDTA against *C. albicans* was significantly less than 6% sodium hypochlorite and 2% chlorhexidine. Chandra et al.<sup>35</sup> found that, with and without adding clotrimazole, the antifungal activity of EDTA was significantly less than 5.25% NaOCl and 2% chlorhexidine.

### MTAD

BioPure MTAD (*Dentsply, Tulsa Dental, Tulsa, OK*) is a root canal irrigant that was introduced by Torabinejad et al.<sup>36</sup> This solution is a mixture of 3% doxycycline, 4.25% citric acid and a detergent (0.5% polysorbate 80).<sup>36</sup> Several studies have evaluated the effectiveness of MTAD for disinfecting root canals. Torabinejad et al. have shown that MTAD is able to remove the smear layer<sup>36</sup> and is effective against *E. faecalis*.<sup>37-39</sup> Furthermore, substantivity of MTAD has been demonstrated for up to 28 days.<sup>40</sup>

There are limited studies on the antifungal activity of MTAD. Using a human tooth model, Ruff et al.<sup>24</sup> found that the antifungal activity of MTAD was significantly weaker than NaOCl and CHX. In another in vitro study, Arslan et al.<sup>41</sup> evaluated the effect of Propolis, BioPure MTAD, 5% sodium hypochlorite and 2% chlorhexidine on *C. albicans* and found that all tested materials

were effective. Mohammadi et al.<sup>40</sup> revealed that the antifungal activity of MTAD was significantly weaker than NaOCl and CHX.

#### Tetraclean

Tetraclean, (*Ogna Laboratori Farmaceutici, Muggiò, Italy*), like MTAD, is a mixture of an antibiotic, an acid and two detergents (propylene glycol and cetrimide).<sup>16</sup> However, the concentration of the antibiotic, doxycycline (50 mg mL<sup>-1</sup>) and the type of detergent (polypropylene glycol and cetrimide) differ from those of MTAD.<sup>16</sup> There is only one study on the antifungal activity of Tetraclean. Mohammadi et al.<sup>42</sup> showed there was no significant difference between the antifungal activity of MTAD and Tetraclean. Furthermore, they revealed that the antifungal activity of NaOCl was significantly greater than MTAD and Tetraclean.

#### Calcium Hydroxide

Calcium hydroxide is a white, odorless powder with the chemical formula Ca(OH)<sub>2</sub> and a molecular weight of 74.08. It has low solubility in water (around 1.2 gL<sup>-1</sup> at 25° C), which decreases with a rise in temperature. It has been demonstrated that the dissociation coefficient of Ca(OH)<sub>2</sub> (0.17) controls the slow release of both calcium and hydroxyl ions.<sup>43</sup>

The antimicrobial activity of Ca(OH)<sub>2</sub> is related to the release of hydroxyl ions in an aqueous environment.<sup>44</sup> Hydroxyl ions are highly oxidant-free radicals that show extreme reactivity with several biomolecules. This reactivity is high and indiscriminate, so this free radical rarely diffuses away from sites of generation.<sup>45</sup> The lethal effects of hydroxyl ions on bacterial cells are probably due to damage to the bacterial cytoplasmic membrane, protein denaturation and/or damage to the DNA.<sup>45</sup>

Although scientific evidence suggests that these three mechanisms may occur, it is difficult to establish, in a chronological sense, which is the main mechanism involved in the death of bacterial cells after exposure to a strong base.<sup>45</sup>

Waltimo et al.<sup>46</sup> reported that *C. albicans* cells were highly resistant to Ca(OH)<sub>2</sub>. Furthermore, they revealed that five *Candida* species, including *C. albicans*, *C. glabrata*, *C. guilliermondii*, *C. krusei*, and *C. tropicalis*, were either equally high or had higher resistance to aqueous calcium hydroxide than did *E. faecalis*.<sup>47</sup> Because *C. albicans* survives in a wide range of pH values, the alkalinity of saturated Ca(OH)<sub>2</sub> solution may not have any effect on *C. albicans*. In addition, Ca(OH)<sub>2</sub> pastes may provide the Ca<sup>2+</sup> ions necessary for the growth and morphogenesis of *Candida*.

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These mechanisms may explain why Ca(OH)<sub>2</sub> has been found to be ineffective against *C. albicans*.<sup>1</sup>

Siqueira et al.<sup>48</sup> investigated the antifungal ability of several medicaments against *C. albicans*, *C. glabrata*, *C. guilliermondii*, *C. parapsilosis* and *S. cerevisiae*. They reported that whereas the paste of Ca(OH)<sub>2</sub> in CPMC/glycerin had the most pronounced antifungal effects, Ca(OH)<sub>2</sub> in glycerin or chlorhexidine and chlorhexidine in detergent also had antifungal activity, but at a lower level than the paste of Ca(OH)<sub>2</sub> in CPMC/glycerin. In another study, Ferguson et al.<sup>21</sup> demonstrated that aqueous Ca(OH)<sub>2</sub> had no antifungal activity when maintained in direct contact with *C. albicans* cells, whereas a combination of Ca(OH)<sub>2</sub> and CPMC was an effective antifungal agent. Siqueira et al.<sup>49</sup> evaluated the effectiveness of four intracanal medicaments in disinfecting the root dentin of bovine teeth experimentally infected with *C. albicans*. Results showed that the specimens treated with Ca(OH)<sub>2</sub>/CPMC/glycerin paste or with chlorhexidine/zinc oxide paste were completely disinfected after one hour of exposure. Furthermore, Ca(OH)<sub>2</sub>/glycerin paste only consistently eliminated *C. albicans* infection after seven days of exposure. However, Ca(OH)<sub>2</sub> mixed with chlorhexidine was ineffective in disinfecting dentin even after one week of exposure.

In summary, fungi have occasionally been found in primary root canal infections, but they appear to occur more often in filled root canals of teeth in which treatment has failed. *C. albicans* is by far the fungal species most commonly isolated from infected root canals. It seems that the combinations of Ca(OH)<sub>2</sub> with camphorated paramonochlorophenol or chlorhexidine have the potential to be used as effective intracanal medicaments for cases in which fungal infection is suspected.

## MTA

MTA materials are a mixture of a refined Portland cement and bismuth oxide, and are reported to contain trace amounts of SiO<sub>2</sub>, CaO, MgO, K<sub>2</sub>SO<sub>4</sub> and Na<sub>2</sub>SO<sub>4</sub>. The major component, Portland cement, is a mixture of dicalcium silicate, tricalcium silicate, tricalcium aluminate, gypsum and tetracalcium aluminoferrate. Gypsum is an important determinant of setting time, as is tetracalcium aluminoferrate, although to a lesser extent. MTA products may contain approximately half the gypsum content of Portland cement, as well as smaller amounts of aluminum species, which provides a longer working time than Portland cement.<sup>50,51</sup> The MTA product powder is mixed with supplied sterile water in a 3:1 powder/liquid ratio. It is recommended that a moist cotton pellet be placed temporarily in direct contact with the material and left until a follow-up appointment. Upon hydration, MTA materials form a colloidal gel that solidifies to a hard structure in approximately three to four hours, with moisture from the surrounding tissues purportedly assisting the setting reaction. Hydrated MTA products have an initial pH of 10.2, which rises to 12.5 three hours after mixing. The setting process is described as a hydration reaction of tricalcium silicate (3CaO·SiO<sub>2</sub>)

and dicalcium silicate (2CaO·SiO<sub>2</sub>), which the latter is said to be responsible for the development of material strength.<sup>51,52</sup>

Investigations have been conducted on the antifungal activity of MTA. Al-Nazhan and Al-Judai<sup>53</sup> showed that freshly mixed and 24-hour set GMTA have an antifungal effect on *C. albicans*. The antifungal effect of MTA might be due to its high pH or to substances that are released from MTA into the media.

Mohammadi et al.<sup>54</sup> revealed that in the freshly mixed, as well as 24 hour-set white MTA cements, fungal growth was observed during a one-hour incubation, whereas by increasing the incubation time, no fungal growth was observed in 24 and 72 hours.

Tanomaru-Filho et al.<sup>55</sup> reported antimicrobial activity of gray MTA, white Portland cement and original Portland cement on *C. albicans*.

Al-Hezaimi et al.<sup>56</sup> evaluated the antifungal effect of WMTA on *C. albicans* and revealed that the concentration of MTA is a significant factor in the antifungal effect of this material. Plates containing a WMTA concentration of less than 25 mg/mL showed no antifungal effect. In contrast, plates containing a concentration of 25 mg/mL showed antifungal activity at 1 and 24 hours, whereas a concentration of 50 mg/mL of WMTA was effective against *C. albicans* during the whole study time. Another investigation compared the antifungal effect of GMTA and WMTA in different concentrations on *C. albicans*.<sup>57</sup> However, GMTA in concentrations lower than 25 mg/mL was significantly more effective against *C. albicans* than WMTA.<sup>57</sup> The results for WMTA and GMTA in concentrations of 25 mg/mL and 50 mg/mL were similar.

On the whole, although there is controversy regarding the antifungal activity of MTA, most conducted studies support its antifungal activity. ✎

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## REFERENCES

1. Siqueira JF, Sen BH. Fungi in endodontic infections. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2004; 97:632-41.
2. Waltimo TM, Haapasalo M, Zehnder M, Meyer J. Clinical aspects related to endodontic yeast infections. *Endod Topics* 2004;9:66-78.
3. Lucas VS. Association of psychotropic drugs, prevalence of denture-related stomatitis and oral candidosis. *Community Dent Oral Epidemiol* 1993;21:313-6.
4. Arendorf TM, Walker DM. The prevalence and intra-oral distribution of *Candida albicans* in man. *Arch Oral Biol* 1980;25:1-10.
5. Dupont B, Graybill JR, Armstrong D, Laroche R, Touze JE, Wheat LJ. Fungal infections in AIDS patients. *J Med Vet Mycol* 1992;30 Suppl 1:19-28.
6. Sen BH, Baski BG. Fungi in endodontic infections. In: *Endodontic microbiology*, ed., Fouad DF, Wiley-Blackwell. 2009:164-194.
7. A.J. Möller. Microbiological examination of root canals and periapical tissues of human teeth. *Methodological studies. Odontol Tidskr* 74 suppl 1966, pp. 1-380.
8. J.C. Baumgartner, C.M. Watts, Xia T. Occurrence of *Candida albicans* in infections of endodontic origin. *J Endod* 2000;26:695-8.
9. Debelian GJ, Olsen I, Tronstad L. Observation of *Saccharomyces cerevisiae* in blood of patient undergoing root canal treatment. *Int Endod J* 1997;30:313-317.
10. Lana MA, Ribeiro-Sobrinho AP, Stehling R, Garcia GD, Silva BK, Hamdan JS, et al. Microorganisms isolated from root canals presenting necrotic pulp and their drug susceptibility in vitro. *Oral Microbiol Immunol* 2001;16:100-105.
11. Siqueira JF, Rôças IN, Moraes SR, Santos KR. Direct amplification of rRNA gene sequences for identification of selected oral pathogens in root canal infections. *Int Endod J* 2002;35:345-51.

12. Sen BH, Piskin B, Demirci T. Observation of bacteria and fungi in infected root canals and dentinal tubules by SEM. *Endod Dent Traumatol* 1995;11: 6-9.
13. Nair PN, Sjögren U, Krey G, Kahnberg KE, Sundqvist G. Intraradicular bacteria and fungi in root-filled, asymptomatic human teeth with therapy-resistant periapical lesions: a long-term light and electron microscopic follow-up study. *J Endod* 1990;16:580-588.
14. Waltimo TM, Sirén EK, Torkko HL, Olsen I, Haapasalo MP. Fungi in therapy-resistant apical periodontitis. *Int Endod J* 1997;30:96-101.
15. Sundqvist G, Figdor D, Persson S, Sjögren U. Microbiologic analysis of teeth with failed endodontic treatment and the outcome of conservative re-treatment. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1998;85:86-93.
16. Molander A, Reit C, Dahlén G, Kvist T. Microbiological status of root-filled teeth with apical periodontitis. *Int Endod J* 1998;31:1-7.
17. Pinheiro ET, Gomes BP, Ferraz CC, Sousa EL, Teixeira FB, Souza-Filho FJ. Microorganisms from canals of root-filled teeth with periapical lesions. *Int Endod J* 2003; 36:1-11.
18. Siqueira JF, Rôças IN. Polymerase chain reaction-based analysis of microorganisms associated with failed endodontic treatment. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2004; 97:85-94.
19. Mohammadi Z. Sodium hypochlorite in endodontics: an update review. *Int Dent J* 2008; 58:329-41.
20. Coolidge ED. The diagnosis and treatment of conditions resulting from diseased dental pulps. *J Nat Dent Assoc* 1919;6:337-349.
21. Ferguson JW, Hatton JF, Gillespie MJ. Effectiveness of intracanal irrigants and medications against the yeast *Candida albicans*. *J Endod* 2002;28:68-71.
22. Sen BH, Safavi KE, Spangberg LS. Antifungal effects of sodium hypochlorite and chlorhexidine in root canals. *J Endod* 1999;25:235-8.
23. Waltimo TM, Orstavik D, Siren EK, Haapasalo MP. In vitro susceptibility of *Candida albicans* to four disinfectants and their combinations. *Int Endod J* 1999;32:421-9.
24. Ruff ML, McClanahan SB, Babel BS. In vitro antifungal efficacy of four irrigants as a final rinse. *J Endod* 2006;32:331-3.
25. Radcliffe CE, Potouridou I, Qureshi R, et al. Antimicrobial activity of varying concentrations of sodium hypochlorite on the endodontic microorganisms *Actinomyces israelii*, *A. naeslundii*, *Candida albicans* and *Enterococcus faecalis*. *Int Endod J* 2004; 37: 438-46.
26. Ayhan H, Sultan N, Cirak M, et al. Antimicrobial effects of various endodontic irrigants on selected microorganisms. *Int Endod J* 1999;32:99-102.
27. Mohammadi Z, Abbott PV. The properties and applications of chlorhexidine in endodontics. *Int Endod J* 2009;42:288-302.
28. Gomes BP, Souza SFC, Ferraz CC, Teixeira FB, Zaia AA, Valdrighi L, Souza-Filho FJ. Effectiveness of 2% chlorhexidine gel and calcium hydroxide against *Enterococcus faecalis* in bovine root dentine in vitro. *Int Endod J* 2003;36:267-75.
29. Gomes BP, Ferraz CC, Vianna ME, Berber VB, Teixeira FB, Souza-Filho FJ. In vitro antimicrobial activity of several concentrations of sodium hypochlorite and chlorhexidine gluconate in the elimination of *Enterococcus faecalis*. *Int Endod J* 2001;34:424-8.
30. Sena NT, Gomes BP, Vianna ME, Berber VB, Zaia AA, Ferraz CC, Souza-Filho FJ. In vitro antimicrobial activity of sodium hypochlorite and chlorhexidine against selected single-species biofilms. *Int Endod J* 2006;39:878-85.
31. Siqueira JF, Rôças IN, Lopes HP, Magalhães FA, de Uzeda M. Elimination of *Candida albicans* infection of the radicular dentine by intracanal medications. *J Endod* 2003;29:501-4.
32. Skoog DA, West DM, Holler FJ. Complex-formation titrations. In: *Fundamentals of Analytical Chemistry*. 7th Ed. Chapter 14. Skoog DA, West DM, Holler FJ, editors. Fort Worth: Saunders College Pub., 1996; pp. 278-301.
33. Hülsmann M, Heckendorff M, Lennon A. Chelating agents in root canal treatment: mode of action and indications for their use. *Int Endod J*. 2003; 36:810-30.
34. Ates M, Akdeniz BG, Sen BH. The effect of calcium chelating or binding agents on *Candida albicans*. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2005;100:626-30.
35. Chandra SS, Miglani R, Srinivasan MR, Indira R. Antifungal efficacy of 5.25% sodium hypochlorite, 2% chlorhexidine gluconate, and 17% EDTA with and without an antifungal agent. *J Endod* 2010; 36:675-8.
36. Torabinejad M, Khademi AA, Babagoli J, Cho Y, Johnson WB, Bazhilov K, Kim J, Shabahang S. A new solution for the removal of the smear layer. *J Endod* 2003; 29:170-175.
37. Torabinejad M, Shabahang S, Apicero R, Kettering JD. The antimicrobial effect of MTAD: An in vitro investigation. *J Endod* 2003; 29:400-3.
38. Shabahang S, Poursmail M, Torabinejad M. In vitro antibacterial efficacy of MTAD and sodium hypochlorite. *J Endod* 2003;29:450-2.
39. Shabahang S, Torabinejad M. Effect of MTAD on *Enterococcus faecalis*-contaminated root canals of extracted human teeth. *J Endod* 2003; 29:576-9.
40. Mohammadi Z, Shahriari S. Residual antibacterial activity of chlorhexidine and MTAD in human root dentin in vitro. *J Oral Sci* 2008;50:63-7.
41. Arslan S, Ozbilge H, Kaya EG, Er O. In vitro antimicrobial activity of propolis, BioPure MTAD, sodium hypochlorite, and chlorhexidine on *Enterococcus faecalis* and *Candida albicans*. *Saudi Med J* 2011;32:479-83.
42. Mohammadi Z, Giardino L, Mombeinpour A. Antibacterial substantivity of a new antibiotic-based endodontic irrigation solution. *Aust Endod J* 2012; 38:26-30.
43. Mohammadi Z, Dummer P. Properties and applications of calcium hydroxide in endodontics and dental traumatology. *Int Endod J* 2011; 44: 697-730.
44. Siqueira JF. Strategies to treat infected root canals. *J Calif Dent Assoc* 2001; 29: 825-37.
45. Siqueira JF, Lopes HP. Mechanisms of antimicrobial activity of calcium hydroxide: a critical review. *Int Endod J* 1999; 32:361-9.
46. Waltimo T, Ørstavik D, Sirén EK, Haapasalo M. In vitro susceptibility of *Candida albicans* to four disinfectants and their combinations. *Int Endod J* 1999a; 32:421-9.
47. Waltimo T, Sirén EK, Ørstavik D, Haapasalo M. Susceptibility of oral *Candida* species to calcium hydroxide in vitro. *Int Endod J* 1999b;32:94-8.
48. Siqueira JF, Rôças IN, Magalhães FA, Uzeda M. Antifungal effects of endodontic medications. *Aust Endod J* 2001;27:112-4.
49. Siqueira JF, Rôças IN, Lopes HP, Magalhães FA, de Uzeda M. Elimination of *Candida albicans* infection of the radicular dentine by intracanal medications. *J Endod* 2003; 29: 501-4.
50. Pariokeh M, Torabinejad M. Mineral trioxide aggregate: a comprehensive literature review-Part I: chemical, physical, and antibacterial properties. *J Endod* 2010; 36:16-27.
51. Roberts HW, Toth JM, Berzins DW, Charlton DG. Mineral trioxide aggregate material use in endodontic treatment: a review of the literature. *Dent Mater* 2008;24:149-64.
52. Darvell BW, Wu RC. "MTA"-a hydraulic silicate cement: review update and setting reaction. *Dent Mater* 2011; 27:407-22.
53. Al-Nazhan S, Al-Judai A. Evaluation of antifungal activity of mineral trioxide aggregate. *J Endod* 2003; 29:826-7.
54. Mohammadi Z, Modaresi J, Yazdizadeh M. Evaluation of the antifungal effects of mineral trioxide aggregate materials. *Aust Endod J* 2006; 32:120-2.
55. Tanomaru-Filho M, Tanomaru JM, Barros DB, Watanabe E, Ito IY. In vitro antimicrobial activity of endodontic sealers, MTA-based cements and Portland cement. *J Oral Sci* 2007; 49:41-5.
56. Al-Hezaimi K, Al-Hamdan K, Naghshbandi J, Oglesby S, Simon JH, Rotstein I. Effect of white-colored mineral trioxide aggregate in different concentrations on *Candida albicans* in vitro. *J Endod* 2005; 31:684-6.
57. Al-Hezaimi K, Naghshbandi J, Oglesby S, Simon JH, Rotstein I. Comparison of antifungal activity of white-colored and gray-colored MTA at similar concentrations against *Candida albicans*. *J Endod* 2006; 32: 365-7.