Co-Dependent Cariology

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Abstract

Clinical caries management has improved significantly during the past decade by way of detection, treatment, and prevention. Now, COVID-19 has brought about even more impetus to alter the practice of dentistry. Providers were directed to deploy caries treatment modalities that do not generate aerosols and yet still control caries disease. Never before has there been more reason to use remineralization agents and novel treatment models including salivary diagnostics and creating dentists who are prodependent cariologists. By walking through a patient case, including traditional radiographs, salivary data, and patient photographs, we can see the benefit of organizations that are "revolutionizing oral health."

Clinical caries management has changed significantly during the past decade. With the start of a new decade, the world is facing a new challenge, COVID-19. More than ever, we are relying on a disease management model of caries, and a non-surgical approach to treatment of dental caries disease.

The American Dental Association created a new Caries Classification System, and systematic reviews regarding sealants as well as non-surgical interventions have led to the creation of new clinical guidelines[1–4] that are more appropriate than ever before due to the inherent lack of aerosol generation. Patients of dentists who are early adopters are being introduced to the concept of remineralization rather than restoration, and "patient-centered care" has been transformed into "person-centered care."

All these changes may be viewed as "disruptive innovation" or merely the natural evolution of our profession based on improved science.[5] Yet, without the co-evolution of a business model that incentivizes disease management, this progress toward creating improved health for our patients will either adapt and affirm the medical management of dental caries or encounter continued resistance through the reliance upon traditional operative dentistry.

There is a dental caries disease management-shaped void in the payment system. Aside from patients with co-morbidities such as cancer, where a dentist is asked to eliminate foci of infection, there is little emphasis paid to and for bidirectionally linking oral health and systemic health. Until dentists are reimbursed to treat the underlying disease of dental caries, our clinical system will remain stuck in the traditional dogma of "drill and fill," a dogma that is dominated by aerosol generating procedures (AGP).[6] Patients deserve and demand better. Every dentist has access to chemistries and processes that have the potential to revolutionize the model of care. Is the profession willing to tap into these technologies in an effort to effectively fight the most prevalent disease on Earth? If not, they risk remaining entrenched in archaic models of prevention that seem to foster the delayed arrival of better evidence and improved outcomes. More importantly, is there a payment system designed to encourage the adoption of better science and therapies without creating an environment of fearful "co-dependent cariologists"?

Despite fluoridation campaigns and public service programs encouraging proper oral hygiene, our traditional therapeutics seem impotent and appear to be no match for a population addicted to sugar, armed naively with nylon bristles and string. Aciduric and acidogenic bacteria continue to evolve and adapt to an oral environment. Salivary secretions continually modify that environment with the potential to buffer plaque acids and confer a state of health.[7] We must accept that we

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Figure 1, Figure 2 — SillHa salivary screening data from a patient before and after consuming arginine bicarbonate taffy (BasicBites).

Tooth health	Cariogenic bacteria	31	Average Ave. :37	Every mouth contains a few of the bacteria that causes cavities. We want to help you keep this level from increasing, or decrease it.
	Acidity	70	High Ave. :43	Your saliva is too acidic and is encouraging the growth of bacteria. We will help you find a way to change this, and lower your risk for cavities.
	Buffer capacity	35	Average Ave. :36	The chemistry of your saliva is considered normal, but you may be able to improve it by eating more protein (especially the amino acid arginine).
Gum health	Blood	13	Low Ave. :22	Congratulations! There is very little blood in your saliva, which indicates your gums are healthy.
	Leukocyte	7	Low Ave. :49	Your saliva contains a low level of white blood cells indicating very little inflammation in your mouth.
	Protein	9	Low Ave. :43	Congratulations! You have very little gingival crevicular fluid in your saliva. This is an indication your gums are healthy.
Oral Cleanliness	Ammonia	100	High Ave. :53	Your saliva contains an abundance of ammonia, which usually indicates the growth of commensal (healthy) bacteria. Sometimes this is linked to halitosis.
Overall comment				The findings above reflect the physiology of your mouth based on saliva and bacterial. These results help us develop a highly personalized plan to prevent cavities, gingivitis, and gum disease. Our goal is to ensure your optimal oral health for years to come.

Figure 2

Tooth health	Cariogenic bacteria	55	High Ave. :37	Your mouth appears to have elevated levels of the bacteria that causes cavities. We will provide you with some strategies to decrease this level.
	Acidity	38	Average Ave. :43	Your saliva appears to be healthy today, but with some changes to your diet we can ensure it stays healthy in the future.
	Buffer capacity	60	High Ave. :36	Congratulations! Your saliva contains all the chemistry necessary to help your teeth and gums stay healthy.
Gum health	Blood	10	Low Ave. :22	Congratulations! There is very little blood in your saliva, which indicates your gums are healthy.
	Leukocyte	18	Low Ave. :49	Your saliva contains a low level of white blood cells, indicating very little inflammation in your mouth.
	Protein	60	High Ave. :43	Your protein levels are elevated, which usually indicates some type of infection. However, this may also be caused by recently eating healthy protein.
Oral Cleanliness	Ammonia	92	High Ave. :53	Your saliva contains an abundance of ammonia, which usually indicates the growth of commensal (healthy) bacteria. Sometimes this is linked to halitosis.

cannot fluoridate our way out of oral disease, we must overcome the stale dogma that dental caries is simply the result of bacteria metabolizing sugar and secreting acid. There are biochemical systems utilized by commensal ("good") bacteria that result in the release of ammonia and generate a basic (capable of remineralization) biofilm. We as a profession are equipped, but not well-positioned, to fully embrace disease management in practice and pave the way for an era of truly efficacious oral health care while also decreasing aerosol-generating procedures.

The health and disease of the mouth is highly dependent upon the physiology and chemistry provided by saliva, yet few clinicians utilize salivary screening. It's often noted that a clinical treatment plan of restorations and calculus removal is largely unaffected by the findings of a saliva analysis; however, the information obtained from basic salivary testing offers objective measurements upon which we can evaluate the success of our therapeutic interventions. The data can act as a motivating conversation-starter for patient engagement, and the objective findings help clinicians prescribe customized interventions that address the individual needs of patients rather than continuing the traditional mindset of applying stronger fluoride with increased frequency[8] (Figures 1 and 2, see Page XX).

Technology such as Sill-Ha and Boka Flow already offer the potential to collect and analyze salivary data that may ultimately improve the evidence base and drive the future of oral health care.[9] The Sill-Ha Oral Wellness System offers the ability to measure seven markers for oral wellness (cariogenic bacteria, acidity, buffer capacity, blood, leukocytes, protein, and ammonia). Boka Flow measures resting salivary flow with the accuracy of three significant figures. Imagine a clinical system wherein a patient's intraoral physiology is understood on a chemical level so the prognosis for treatment is improved with tailored therapeutic interventions based on objective data, and dentists receive financial compensation for improving and maintaining

Figure 3, Figure 4 — SillHa salivary screening data from a patient before and after initiating sodium bicarbonate rinse.

Tooth health	Cariogenic bacteria	44	Average Ave. :37	Every mouth contains a few of the bacteria that causes cavities. We want to help you keep this level from increasing, or decrease it.
	Acidity	89	High Ave. :43	Your saliva is too acidic and is encouraging the growth of bacteria. We will help you find a way to change this, and lower your risk for cavities.
	Buffer capacity	16	Low Ave. :36	Your saliva seems to be lacking some critical chemistry. You would benefit from using baking soda toothpaste and/or using MI Paste at bedtime.
Gum health	Blood	17	Average Ave. :22	Your saliva contains a small amount of blood, which usually indicates gingivitis, although it could also be due to recent brushing or flossing.
	Leukocyte	36	Low Ave. :49	Your saliva contains a low level of white blood cells, which indicates there is very little inflammation.
	Protein	32	Low Ave. :43	Congratulations! You have very little gingival crevicular fluid in your mouth. This is an indication your gums are healthy.
Oral Cleanliness	Ammonia	47	Average Ave. :53	Your saliva contains an abundance of ammonia. You may want to try and increase this level by consuming more protein, especially when you snack.
Overall comment	The findings above reflect the physiology of your mouth based on saliva and bacteria. These results help us develop a highly personalized plan to prevent cavities, gingivitis, and gum disease. Our goal is to ensure your optimal oral health for years to come.			

health. That is the epitome of value-based care.

In 2019, the Massachusetts Public Employees Fund created a clinical practice (the Alliance Dental Center LLC) to serve as an incubator for improving oral health care processes and systems while also providing traditional restorative dental treatment. Before COVID-19, novel therapeutics were offered to patients along with evidence-based treatments based on clinical salivary data in an effort to decrease disease incidence. During the global pandemic the ADC was able to keep employees working and treating patients using teledentistry. For example, patients at high risk for tooth decay were contacted by phone to review oral health goals and proactively apply preventive strategies using motivational interviewing. After the initial patient contact, patient-specific kits were assembled containing resources, educational materials, and preventive agents or therapies that could balance risk factors.

Current theories in behavior change indicate patient engagement is paramount to successful use of preventive agents, and consequently the clinical staff at the Alliance Dental Center received intensive training in motivational interviewing prior to beginning to offer clinical services.[10] Rather than prescribing a preventive product, patients are encouraged to select their preferred caries management strategy and create their own oral health goal. A matrix was created for the clinical team to identify preventive products that would "fit" into the patient's lifestyle and preferences. For example, some patients prefer to simply use a different toothpaste, while others may choose to change their diet or begin chewing gum in between meals (Figure 3).

The therapeutics and preventive products used at the Alliance Dental Center reflect the tremendous strides in the past decade within the field of clinical cariology. Although fluoride will continue to be the most evidence-based preventive and therapeutic agent for the time being, the body of research in novel therapies has been the subject of three separate International Conferences on Novel Anticaries and Remineralization Agents (ICNARA 1, 2 and 3).[11–13] These conferences have resulted in entire publications focused on the future of improving the clinical success of treating dental caries

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Figure 4

Tooth health	Cariogenic bacteria	61	High Ave. :37	Your mouth appears to have elevated levels of the bacteria that causes cavities. We will provide you some strategies to decrease this level.
	Acidity	2	Low Ave. :43	Congratulations! The pH of your saliva is considered "Very Good." While this helps prevent cavities, you may notice more tartar forming on your teeth.
	Buffer capacity	100	High Ave. :36	Congratulations! Your saliva contains all the chemistry necessary to help your teeth and gums stay healthy.
Gum health	Blood	11	Low Ave. :22	Congratulations! There is very little blood in your saliva, which indicates your gums are healthy.
	Leukocyte	38	Average Ave. :49	The level of white blood cells in your saliva is elevated, probably due to gingivitis or other sores in your mouth.
	Protein	24	Low Ave. :43	Congratulations! You have very little gingival crevicular fluid in your mouth. This is an indication your gums are healthy.
Oral Cleanliness	Ammonia	1	Low Ave. :53	Your saliva has decreased ammonia content, which indicates an elevated risk for tooth decay. Consuming more protein can help raise this level.
Overall comment	The findings above reflect the physiology of your mouth based on saliva and bacteria. These results help us develop a highly personalized plan to prevent cavities, gingivitis, and gum disease. Our goal is to ensure your optimal oral health for years to come.			

around the world, with many of the therapies being non-aerosol-generating procedures. As we move forward and treat patients in light of infectious diseases like COVID-19, we all are called to look to innovative and less invasive means of offensively preventing and treating oral disease.

The Alliance Dental Center strives to deliver innovative care that is developed based on recognition of the evidence and the application of synergistic therapies that many would consider novel. Rather than continuing what the clinical team felt was an ineffective strategy of disinfecting the mouth with broad spectrum antimicrobials and creating fluorapatite, chitosan technology was identified as offering a new mechanism for biofilm removal and control. Originally created for military purposes of wound management on the battlefield, chitosan rinses are now available over the counter and specifically designed for oral use. This remarkable technology appears to have all the characteristics of an ideal mouthwash with a positive charge, basic pH, and the ability to attract moisture, while also disrupting bacterial cell membranes. Peer-reviewed clinical studies have already demonstrated utility in treating even the most severe hyposalivation (for example, patients undergoing chemotherapy, or those who suffer from medication induced xerostomia) with a minimal quantity.[14]

Figure 5 — The clinical matrix used at the Alliance Dental Center to identify preventive modalities that are customized to patient's preference and desired therapeutic outcome.

		Desired treatment effect				
Patient preference for delivery		Antibacterial	Neutralize acidic PH/ promote salivary flow	Improve the Oral Microbiome	Remineralize or Improve Enamel	Improve Salivary Chemistry
	Toothpaste	Closys 5000 ppm F toothpaste	Baking soda toothpaste	Xylitol toothpaste Arginine toothpaste	5000 ppm F w/TCP MI Paste One	MI Paste One
	Gel	Livionex Carbamide peroxide Stannous fluoride gel	Carbamide peroxide	Xylitol gel Carbamide peroxide	Stannous fluoride MI Paste Plus Enamelon Curodont ReminPro	MI Paste MI Paste Plus ReminPro
	Rinse	Synedent/Moisyn Closys CTx4 rinse Listerine Chlorhexidine	Baking soda water Synedent/Moisyn CTx3/4 treatment rinse Xylitol	Xylitol water Xylitol rinse	Synedent FLX ACT mouthwash Fluoride mouthwash	Salivamax
	Spray	Moisyn Xylitol spray	Moisyn spray CTx2 spray	Xylitol spray CTx2 spray		CTx2 spray
	Lozenge/ Mint/Gum	Dentiva Salese Loloz	Dentiva Salese Xylitol gum Sugar-free gum Pilocarpine lollipops	Probiora Xylitol candies/mints Loloz		Dentiva Salese
	Food Product	Cranberry extract Licorice root extract	Basic Bites	Xylitol granules Erythritol granules	Spinach Tea Fluoridated tap water	Increase protein in the diet especially with arginine-rich foods

The table is meant to identify caries management strategies that can be easily implemented by individual patients based on their personal preferences. Only one product should be recommended to the patient at each appointment and subsequent recare visits should be used to inquire into the successful use of the recommended product. All patients should be encouraged to increase contact time of toothpaste with their teeth by "leaving the foam alone."

Probiotics, prebiotics, and protein scaffold remineralization strategies like P11-4 (also known as Curodont) take clinical interventions to new levels that haven't been appreciated by randomized controlled trials, but outcomes measurement can better inform their strategic use. Progressive clinicians can provide probiotic lozenges to a patient in an attempt to "seed" a healthy biofilm, and dispense lozenges for patients to use daily at bedtime.[15] The commensal biofilm can be nurtured further by adding a prebiotic such as dietary protein rich in arginine, which serves as metabolic substrate creating the generation of basic plaque so that pathogen growth is suppressed.[16] And, if a lesion does happen to form, the application of P11-4 can create a biomimetic precipitation of peptide chains that penetrate into early demineralized surfaces, unlike any remineralization chemistry we've seen before.[17] In our practice, we are able to treat an initial carious lesion with a liquid-soaked sponge rather than a drill, a mode of treatment that can be safely delivered in the time of a pandemic.

All of these disruptive innovations require a value-based reimbursement system to incentivize their clinical utilization and widespread adoption. At the Alliance Dental Center, caries susceptibility testing is reimbursed in order to facilitate screening and intervention with appropriate therapeutics. The clinical team is held accountable for health outcomes measured via a decrease in caries risk. The forward-thinking board of directors of the Massachusetts Public Employees Fund and staff at the Alliance Dental Center are on the leading edge of pursuing improved health unhindered by a lack of evidence for the clinical utility of improved diagnostics and therapies. Yet often, the simplest modification of raising the intraoral pH to a basic level using sodium bicarbonate rinse achieves results in a short period of time.(Figures 4, see Page XX, and Figure 5).

The rest of the dental ecosystem is at least one step behind. At the moment, most dental practices don't assess the caries risk of patients at all visits. Worse still is the fact that some payers reject claims containing a caries risk assessment, or refuse to reimburse for more

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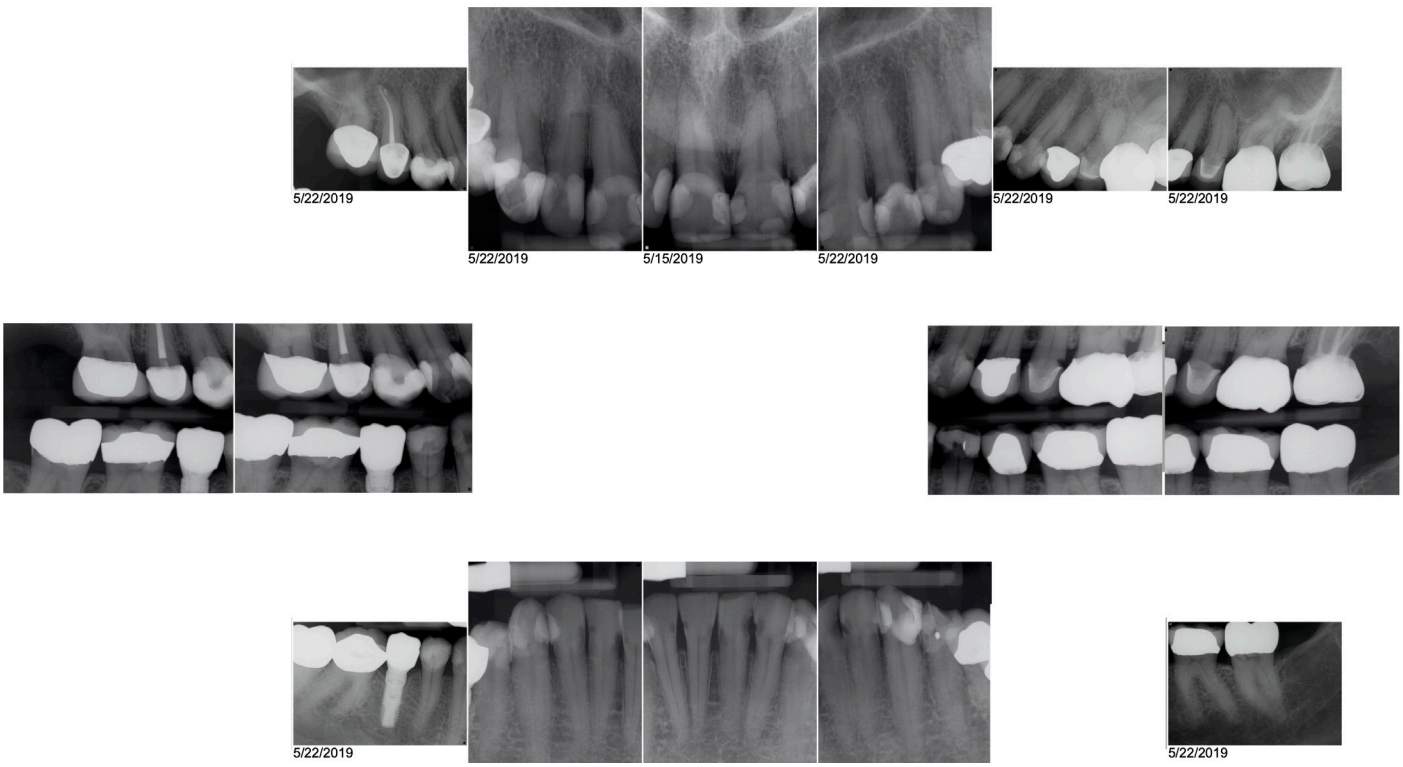
Figure 6 — Radiographic presentation of the patient's dental caries disease secondary to medication induced xerostomia.



than one risk assessment every three years. However, without the use of caries risk assessment codes, clinical environments are unable to track the disease prevalence and incidence within their systems. Every practice should be able to calculate the health of the population it treats using metrics within its practice management software; however, our data systems struggle to calculate outcomes. Instead, the majority of electronic dental records are designed to calculate financial gains and losses rather than the incidence of oral disease. Practice level metrics belong in every dental office, not just the meetings of the Dental Quality Alliance. The Dental Caries Management Virtual Practicum (available online for free) offers a comprehensive experience for all members of the dental team to create health measurement in any practice setting using any computer-based practice management system.[18]

Dr. Bob Barkley wrote in 1972 in *Successful Preventive Dental Practices*, ". . . disease management programs are finally gaining respectability as bonafide tools of dentistry."[19] Yet, nearly 50 years later, our fee-for-service reimbursement system continues to incentivize a surgical model that leads to more restorations rather than less disease. It's doubtful that G.V. Black thought it would take more than a century for his famous statement, "The day is surely coming, and perhaps within the lifetime of you [clinicians] before me when we will be engaged in practicing preventive rather than reparative dentistry" to come true.[20]

Perhaps value-based oral health care and our response to a global pandemic will usher in the practice of true preventive dentistry as G.V. Black envisioned. As optimistic as some of us are, something is holding us back from achieving the goal of an oral health care ecosystem. The profession has never been better prepared to treat oral disease and measure our success — the science, therapies, clinicians, and patients are all ready and eager. It is up to the profession to guide the new era of oral health care, wherein patients stop developing disease and payment is linked to the creation of health. The clinician who fears the pitfalls of co-dependent cariology may find some solace in the realization that once value-based reimbursement becomes a reality, every general dentist is capable of becoming a prodependent cariologist.

Figure 7 — Baseline SillHa salivary screening data demonstrating an oral environment highly prone to continued demineralization and disease.

Tooth health	Cariogenic bacteria	0	Low Ave. :37	Studies have shown that higher cariogenic bacteria count makes the teeth more vulnerable to caries.
	Acidity	85	High Ave. :43	Studies have shown that higher salivary acidity makes the teeth more vulnerable to caries.
	Buffer capacity	25	Low Ave. :36	Studies have shown that lower buffer capacity (resistance to acid) makes the teeth more vulnerable to caries.
Gum health	Blood	55	High Ave. :22	Studies have shown that gingival inflammation, oral damage, and oral mucosal ulcer increase blood in saliva.
	Leukocyte	84	High Ave. :49	Studies have shown that gingival inflammation increases leukocytes in saliva.
	Protein	78	High Ave. :43	Studies have shown that higher periodontal disease-causing bacteria count and gingival inflammation increase protein in saliva.
Oral Cleanliness	Ammonia	7	Low Ave. :53	Studies have shown that higher bacteria count in the oral cavity increases ammonia in saliva, causing bad breath, etc.

Clinical case

Patients with medication-induced xerostomia (also known as MIX disease) present a unique clinical challenge that requires aggressive caries disease stabilization and intensive home prevention prior to providing long term restorations.

A 52-year-old female presented with a two-year history of periapical pathology on multiple teeth identified by her primary care physician via MRI, resulting in chronic sinusitis and hospitalization. Due to personal circumstances and a complicated medical history consisting of lupus, attention deficit hyperactivity disorder (ADHD), anxiety, depression, insomnia, fibromyalgia, anemia, gastroesophageal reflux disorder (GERD), and gastric bypass, she delayed seeking dental care. Upon presenting for care she was identified as an extreme dental caries risk secondary to medication-induced xerostomia, resulting in what would be traditionally referred to as "rampant dental caries disease" with multiple non-restorable teeth (Figure 6, see Page XX).

The patient's salivary assessment via SillHa data verified her acidic oral environment, lack of buffering capacity, overgrowth of cariogenic bacteria, and periodontal inflammatory markers, which became a baseline measurement to assess the patient's progress toward health in the future (Figure 7).

She was immediately treated with a full mouth application of silver diamine fluoride, and she selected to begin using a mouthwash (Moisyn) that would alleviate her constant xerostomia. A compounding pharmacy was contacted to create pilocarpine lollipops (5 mg pilocarpine in a 2g sorbitol/xylitol base), which the patient was instructed to use as needed throughout the day. At her second visit, she remarked that the mouthwash seemed to be helping because she had noticed a decrease in oral discomfort. Nonsurgical periodontal therapy was provided along with a second application of silver diamine fluoride to all surfaces. She was referred to an endodontist for evaluation and treatment of her symptomatic teeth and she consented to an initial treatment plan consisting of the elimination of all active caries disease and restoration of all surfaces with conventional and resin modified glass ionomer.

Over the course of her eight-month treatment plans the patient had three extractions, and five teeth were treated with endodontics. All existing restorations were removed and replaced with glass ionomer (and resin-modified glass ionomer) restorations with the intention to use the large restorations as build-ups for full coverage restorations in the future (Figures 8 and 9). She continues to use the Moisyn rinse every night, pilocarpine lollipops as needed, and tries to sip on xylitol water throughout the day (4 grams of xylitol in 16 ounces of water). She reports an improved quality of life and looks forward to her dental visits.

Although her salivary analysis data does not show the creation of an altogether stable and low caries risk environment, the screening metrics allow for continued evaluation of the patient's progress. Further use of her salivary data will hopefully demonstrate continued stabilization of her oral condition. ●

Figure 8 — Clinical presentation of the patient's dentition after restorative treatment with resin modified glass ionomer and conventional glass ionomer.

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