Cocaine and methamphetamine: Pharmacology and dental implications

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PRACTICAL IMPLICATIONS OF THIS RESEARCH

- Clients presenting for oral care may be illicit drug users.
- Drug abuse is associated with multiple, serious oral health problems.
- Oral health care professionals need to recognize the prevalence, pharmacology, and adverse effects of illicit drugs, such as cocaine and methamphetamine, to provide effective treatment.

ABSTRACT

Background: Epidemiological studies have shown that illicit drug use is a persistent and growing problem in our society. Methamphetamine and cocaine are at the top of the list of stimulants commonly abused. There is a need for a disease-targeted approach to the dental management of clients who use these drugs. **Method:** A review of the literature was conducted to identify the most up-to-date information for the diagnosis and treatment of dental clients who abuse methamphetamine and cocaine. Databases in the University of Toronto library system were searched for peer-reviewed articles, written in English, and containing data relevant to clinical decision making. Textbooks were chosen from a list of reference materials provided by the National Dental Examination Board. All cited articles were published within the past 5 years. **Results and Discussion:** There is robust literature on the treatment of individual signs and symptoms associated with methamphetamine and cocaine use. However, there is a dearth of information on the comprehensive, client-centred oral health care that these individuals require. **Conclusion**: This article reviews the best practices to guide the clinician from the initial oral diagnosis appointment to the maintenance of care, including the pharmacological actions of these drugs of abuse, the specific challenges faced in providing care for this client population, and scientifically based treatment considerations to maximize prognosis.

RÉSUMÉ

Contexte : Des études épidémiologiques ont montré que l'utilisation de drogues illicites est un problème persistant et grandissant dans notre société. La méthamphétamine et la cocaïne figurent en tête de liste des stimulants qui font couramment l'objet d'abus. Un besoin existe pour une approche axée sur la maladie pour la gestion dentaire de clients qui consomment ces drogues. **Méthodologie :** Une revue de la littérature a été réalisée pour cibler l'information la plus à jour pour le diagnostic et de traitement des clients dentaires qui consomment de façon abusive de la méthamphétamine et de la cocaïne. Des recherches ont été effectuées dans les bases de données du réseau de bibliothèque de l'Université de Toronto pour trouver des articles évalués par les pairs, rédigés en anglais, et comprenant des données pertinentes à la prise de décision clinique. Des manuels ont été sélectionnés dans une liste de documents de référence fournie par le Bureau national d'examen dentaire. Tous les articles cités ont été publiés au cours des 5 dernières années. **Résultats et discussion :** Il existe une documentation solide sur le traitement des signes et des symptômes individuels associés à l'utilisation de la méthamphétamine et de la cocaïne. Cependant, il y a une pénurie d'information sur les soins buccodentaires complets, axés sur le client, que ces personnes requièrent. **Conclusion :** Le présent article examine les meilleures pratiques pour guider le clinicien à partir du rendez-vous de diagnostic buccodentaire initial jusqu'au maintien des soins, y compris les actions pharmacologiques de ces drogues utilisées de façon abusive, les défis précis auxquels il faut faire face pour la prestation de soins à cette population de clients et le plan de traitement fondé sur la science pour optimiser le pronostic.

Keywords: addiction, cocaine, illicit drugs, methamphetamine, pharmacology, xerostomia
CDHA Research Agenda category: risk assessment and management

INTRODUCTION

Methamphetamine and other illicit drugs such as cocaine are profound central nervous system (CNS) stimulants producing powerful euphoric effects in the user, along with high energy and increased self-confidence. The current therapeutic use of methamphetamine hydrochloride is primarily for the management of attention deficit disorder, refractory obesity, and narcolepsy.[1,2] Historically it was also used for the treatment of fatigue and depression because it alleviates daytime sleepiness, causes increased physical performance, and enhances mood.[3] Cocaine was medicalized for its local anesthetic properties.[4] These drugs are illegal due to their high dependence and addiction liability. Illicit drug use is a burden not only for the user but also for the government, consuming billions of dollars in criminal justice and health care system resources.[5]

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Between 2010 and 2017, methamphetamine possession charges in Canada increased by 590%,[6] with the highest numbers reported in British Columbia, Alberta, Saskatchewan, and Quebec. Cocaine, although still widely used, it is being replaced with methamphetamine, which is now a cheaper, more readily available alternative.[7] The Royal Canadian Mounted Police (RCMP) estimates that 97% of methamphetamine in Canada is made domestically in clandestine laboratories. Canada is also a major exporter of methamphetamine, with distribution reaching Asian markets through Japan and Australia.[8] Cocaine is processed and imported from South America through transamerican routes to major Canadian hubs such as Toronto and Vancouver.[9]

According to the most recent Statistics Canada report, approximately 1 in 5 Canadians over the age of 15 experience a substance abuse disorder over their lifetime.[10] Drug use in the homeless youth population, particularly crack cocaine and methamphetamine, increases the likelihood of criminal behaviour such as theft and drug dealing.[11] Injection drug use also increases the likelihood of HIV and Hepatitis C infection due to risky behaviours such as syringe sharing and unprotected sex.[12] A longitudinal study of street-involved teens in Vancouver showed 30.7% of participants were hospitalized within 6 months of the study. The top 3 reasons for hospitalization were mental illness, physical trauma, and drug-related issues. Hospitalization in this population was significantly associated with a past diagnosis of a mental illness, frequent cocaine use, non-fatal overdose, and homelessness.[13] In 2015, Ontario coroners reported 387 deaths due to cocaine and other stimulant use.[14] This situation highlights the impact of social and economic barriers to care that vulnerable groups face and the importance of early intervention.[15]

There are many scholarly articles and case reports describing the oral implications of drug abuse, but little clinical information is available for the comprehensive treatment of oral conditions in this population. This review seeks to address this gap in the literature by identifying the most important considerations for the clinical evaluation, treatment, and prognosis of clients who abuse drugs and synthesizing them into a guide for client-centred care.

METHODS

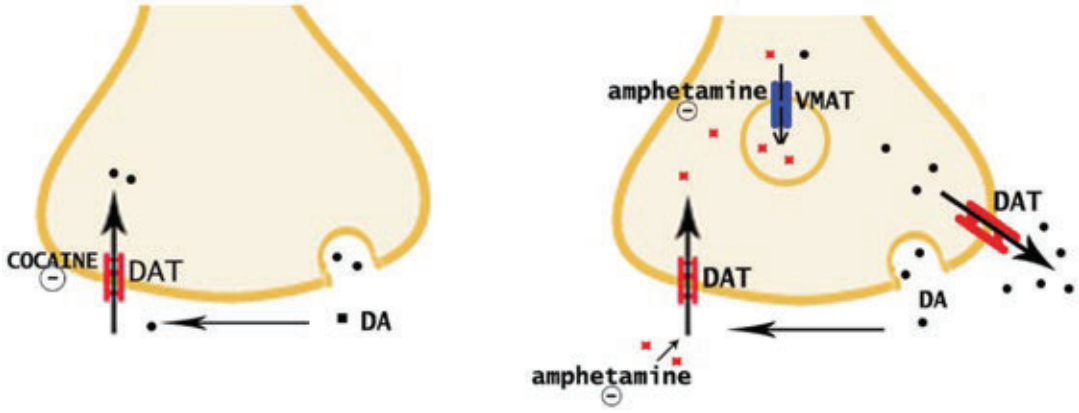
A literature review was undertaken to identify the oral complications, best treatment options, and benefits of pharmacological intervention for the oral reconstruction and maintenance of oral health in the methamphetamine and cocaine user. Databases in the University of Toronto library system were searched to locate relevant peer-reviewed articles written in English and published in the past 5 years. Textbooks were obtained from the National Dental Examination Board and reviewed for pertinent content. Analysis of the articles retrieved revealed that the halting of drug abuse, treatment of xerostomia, and an intense preventive regimen play the most important roles in the prognosis of the client.[16,17]

RESULTS AND DISCUSSION

Mechanism of actions of cocaine and methamphetamine

Addiction is defined as a high motivation to acquire and use a drug regardless of its negative effects. Addictive drugs act on the mesolimbic dopamine system whose origins begin in the ventral tegmental area (VTA) and project to the nucleus accumbens, the amygdala, the hippocampus, and the prefrontal cortex. All addictive drugs result in a higher concentration of dopamine release into the nucleus accumbens and prefrontal cortex. In an evolutionary sense, the euphoric sensation that accompanies the release of dopamine in the VTA reinforces and rewards an adaptive behaviour. Normally this reward system functions to motivate an individual to obtain food, seek shelter, reproduce, and adapt to conditions in the environment. The strong reinforcing effects of dopamine also extend to maladaptive behaviour. Thus, the seeking and consumption of a dopamine-releasing drug, sometimes through extreme means, becomes the reinforced behaviour. The urge can be so overwhelming that drug-seeking behaviours can destroy the individual's social and professional life.[18]

Figure 1. Mechanism of action of cocaine and amphetamines on dopamine release in the mesolimbic system



Cocaine increases the dopamine concentration in the nucleus accumbens through inhibition of the dopamine transporter (DAT), which functions to take unbound dopamine back into the axon terminals. Amphetamines competitively inhibit the DAT leading to an increase in synaptic dopamine. In addition, they interfere with the vesicular monoamine transporter leading to an increase in intracellular dopamine (Figure 1). This results in a reversal of the DAT transporter, further increasing synaptic dopamine.[18]

Also relevant is the inhibitory stimulation of alpha-2 receptors in the salivary nuclei of the CNS. It is believed that this is the primary cause of stimulant-induced xerostomia in these clients and not peripheral inhibition.[19]

Impacts on the oral cavity

Cocaine and methamphetamine use become more apparent as the individual's tolerance increases and they resort to more dangerous routes of administration to increase bioavailability. The acutely intoxicated individual may present as alert, euphoric, agitated, and confused.[18] Extraoral exam may reveal crepitus, hypertrophic muscles of mastication, and facial flushing. Elevated blood pressure, tachycardia, and ventricular arrythmias are often present.[18] A social history of these individuals can give the dental professional important clues when suspecting a drug dependency issue. These clients will often have a low income, low educational level, and an alcohol and nicotine addiction.[20]

The clinical signs of amphetamine abuse in the oral cavity, sometimes called "meth mouth," include severe xerostomia, gingivitis, periodontitis, severe dental caries, and fractured teeth.[21,22] In 100 methamphetamine users evaluated by Rommel et al., 72% reported dry mouth, 68% reported jaw clenching, and 47% reported temporomandibular pain. In addition, 83% of study participants had a salivary buffering capacity below 5.5 pH.[23] Methamphetamine users score higher on the decayed missing filled teeth (DMFT) index than non-users.[24]

Another study from the Federal University of Brazil showed 37.5% of cocaine-addicted individuals had an oral mucosal lesion—2.87 times greater than the non-addicted study group. The 3 most common oral lesions were traumatic ulcers, actinic cheilitis (7.5% of the detected lesions each), and fistulae associated with retained roots after carious fracture (5% of detected lesions).[20] When cocaine is applied directly to the gum it can lead to chemical erosion of enamel and dentin, and gingival recession.[25] DMFT scores for cocaine users were shown by Cury et al[26] to be higher only in the decayed parameter. Oronasal defects are more common with cocaine use but are seen when either drug is consumed nasally.[25] Key oral signs and symptoms in methamphetamine and cocaine users are shown in Table 1.

With the protective functions of saliva absent, rampant caries can progress unchecked. The typical presentation is the apple core pattern of tooth decay. Caries are often seen deepest in the cervical area of the tooth and progress apically and occlusally, undermining enamel and causing gross decay. The rapid progression is also facilitated by toxic chemicals from the smoked drug vapours. Flaking of tooth structure and whole tooth fractures are commonly a result of the drug user's bruxism and clenching[21] and undermined enamel. Figure 2 shows the oral destruction associated with methamphetamine abuse. Clients who abuse drugs present prosthodontic challenges including loss of posterior support, secondary occlusal trauma, generalized erosion/attrition, and loss of vertical dimension of occlusion.[30]

Table 1. Oral manifestations of methamphetamine and cocaine use[27–29]

Oral manifestations	Methamphetamine use	Cocaine use
Signs	Rampant caries Buccal/interproximal cervical caries Darkly stained, crumbling teeth Missing teeth Decreased salivary pH Erosion Candidiasis infection Cheilitis Glossitis Periodontal disease	Decay Attrition Erosion Decreased salivary pH Ulcerated, erythematous gingival lesions Periodontal disease Gingival recession
Symptoms	Severe xerostomia Bruxism Attrition Temporomandibular joint pain Jaw clenching Myofacial pain	Xerostomia Bruxism Temporomandibular joint pain *Oronasal defects:* Epistaxis Rhinitis Nasal crusting Chronic sinusitis Palatal perforation

Figure 2. A 60-year-old male presenting with "meth mouth"

A postextraction image shows severe cervical caries, recurrent class 5 lesions, fractured/chipped teeth, compromised periodontium, and collapsed bite. A social and family history revealed a work injury that led to a loss of income, marriage, and family support. The client began to experience depression and anxiety along with other medical issues, eventually leading to the start of drug abuse.

Interprofessional role of the dental practitioner

As with all clients, a thorough medical history should be taken to determine the presence of substance abuse and other comorbidities. If the signs and symptoms of drug abuse are present, a medical consultation should be initiated to determine a diagnosis and initiate interprofessional treatment. This should always be done with the client's consent.[31]

When a client evaluation suggests the presence of substance abuse, it must be carefully explored with the client. As with the client described in Figure 2, a detailed social and family history can help when broaching the subject of drug abuse. Beginning with a private presentation of the findings, the practitioner should address the likely etiology including the possibility of drug abuse with the client. If the client admits to having a substance abuse problem, the next step is to explain the oral and overall consequences of drug abuse including its prognosis with and without treatment. With permission, a referral to professional therapy should follow. If the client is reluctant to admit to a substance abuse disorder, the dental professional is put in the uncomfortable but ethically important position of confronting the client. The client's response may be unpredictable but can be positively influenced by a professional and empathetic approach. If the client continues to deny a substance abuse issue, the

Table 2. Precautions associated with the dental management of cocaine and methamphetamine users

Dental management	Recommended protocol	Notes
Antibiotics	No issue unless other contraindications present.	
Analgesics	Analgesics should be limited to non-narcotics. The current ibuprofen and acetaminophen protocol should be followed. If necessary, narcotics of adequate strength can be used in consultation with the primary provider who is managing the client's substance abuse program. Narcotics of adequate strength, with limited doses for the shortest possible amount of time and no refills, should be prescribed. Consider having a third party dispense and monitor appropriate drug use.	
Anesthesia	Epinephrine-free local anesthetic is a safer alternative for cocaine and methamphetamine users. If the client has abstained from cocaine or methamphetamine for more than 12 hours, regular epinephrine-containing local anesthetic can be used.	Epinephrine can lead to cardiovascular emergencies in cocaine and methamphetamine users.
Allergies	No issue unless other contraindications present.	
Anxiety	For the recovering addict, nitrous oxide-oxygen should be considered first. Mild sedation with a short-acting benzodiazepine can be considered with physician consultation.	Acute withdrawal symptoms can lead to unpredictable sedation.
Bleeding	No issue unless other contraindications present.	Alcohol addiction is common among drug users.
Breathing	No issue unless other contraindications present	
Blood pressure	Blood pressure and pulse should be monitored in these clients.	Unstable/abnormal vital signs can be seen in cocaine and methamphetamine users.
Cardiovascular	Increased risk of cardiac arrythmias, stroke, and myocardial infarctions.	
Drugs	Epinephrine can lead to cardiovascular emergencies in cocaine and methamphetamine users.	
Emergencies	An appropriately stocked "crash cart" or emergency kit should be available for the management of cardiovascular emergencies. Naloxone should be available in the event of an opioid overdose.	

Note: Adapted from *Little and Falace's Dental management of the medically compromised patient,* 9th ed. St. Louis MO: Elsevier; 2018. p. 590.

Table 3. Common complaints and clinical findings indicative of xerostomia

Complaints or symptoms	Signs	Salivary flow test procedure
Soreness or burning mouth, lips or tongue Sleep interruptions due to thirst or oral discomfort Difficulty chewing, speaking, swallowing or wearing prosthesis Difficulty clearing oral debris Complaints of dryness Altered taste Altered sense of smell Aversion to eating dry foods	Dry, sticky oral tissues Ropey, thick, frothy saliva Cracking/fissuring of the corners of the mouth or tongue Stale breath or halitosis Recurrent candida infections Increased dental decay Increased tartar deposits Red gums that bleed easily	1. The client is first instructed to collect their saliva in a small calibrated container over 10 minutes. 2. The client is then instructed to repeat the process while chewing on a flavoured paraffin pellet to stimulate salivation. 3. A resting flow rate of <0.1 mL/min or stimulated flow rate of <0.5 mL/min is indictive of xerostomia.

only option is to provide the best oral care possible for them. However, if evidence of self-harm or harm to others is present, then it is appropriate to notify mental health or legal authorities.[21]

Emergency management and treatment planning

The client with a substance use disorder usually only presents to the dental office in between drug binges or in an attempt to regain control of their health.[32] In the case where a client presents with the typical oral manifestations of "meth mouth" or its cocaine-induced equivalent, emergency disease management should be initiated. Figure 3 summarizes the protocol for treatment planning with clients presenting with the signs and symptoms of methamphetamine or other stimulant use. A typical new client exam should be conducted, including radiographs and vitality testing where indicated. Table 2 highlights the precautions that should be taken when treating clients with cocaine or methamphetamine addiction. After a dental and periodontal diagnosis is acquired, the practitioner should proceed to pain management. For hopeless teeth, much of the client's pain can be alleviated through extractions.[33] Dental professionals should avoid narcotic analgesics and recommend instead non-steroidal anti-inflammatory drugs.[17]

Before any definitive restorative work is done, the client should sign a consent form outlining the impact of continued methamphetamine, cocaine or other stimulant use on the prognosis of final restorations.[34] Often because of the number of compromised teeth and referred pain, pulp testing may be unreliable, leading to a misdiagnosis of individual tooth prognoses. In these instances, 2-stage caries management should be initiated and will serve to reduce client discomfort, promote remineralization, and allow for more accurate pulp testing in the future. Final restorations can be placed once an accurate diagnosis has been made for each tooth.

The American College of Prosthodontics recommends postponing prosthodontic treatment until the client is no longer dependent on stimulants and is emotionally stable and motivated.[35] The loss of posterior support, lack of suitable abutment teeth, and xerostomia will create challenges in the retention and stability of dentures. Implants can be a valuable option for restoring function for these clients, but careful evaluation must be taken beforehand. Methamphetamine use has been shown to chronically lower bone matrix dentistry (BMD) in these clients.[36] A lower BMD, history of periodontitis, and common concurrent smoking addiction increases early and late implant failure rates and lowers implant success rate.[35,37,38]

Extractions should be performed on severe periodontally compromised teeth that are non-restorable. Although not definitely proven, recent case studies and reports show a possible association between methamphetamine use and

Figure 3. Dental management protocol in cases of methamphetamine- and cocaine-induced rampant caries

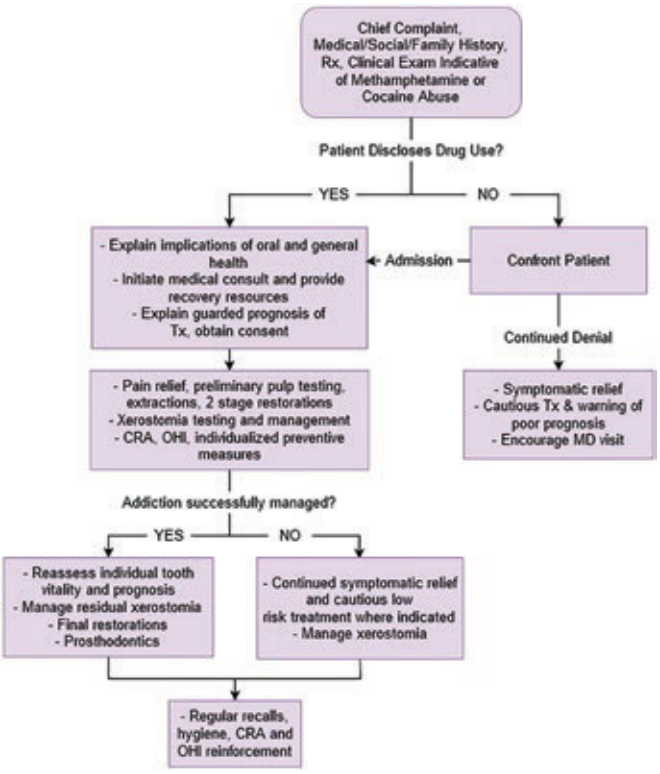


Table 4. Preventive regimens based on individual caries risk as outlined by the CAMBRA protocol[42]

Risk level	Antimicrobials	At-home fluoride	Professional CRA and F^-	Xylitol and/or baking soda
High	Chlorhexidine 0.12% rinses for 1 min daily for 1 week each month	Rx 5000 ppm fluoride toothpaste twice daily	CRA every 6 months and fluoride varnish every 6 months	Xylitol gum or mints, 8 g daily
Extremely high	Chlorhexidine 0.12% rinses for 1 min daily for 1 week each month	Trays for home application 5000 ppm $fluoride^-$ gel qd x 5 min	CRA every 3 to 6 months and fluoride varnish every 3 to 6 months	Xylitol gum or mints, 8 g daily, and baking soda rinse 4 to 6 times daily

Table 5. Pharmacological treatment options for xerostomia

Drug	Mechanism of action	Dose	Adverse effects
Cevimeline (Evoxac®)	Agonist at the muscarinic acetylcholine receptors M_1 and M_3	30 mg TID	Nausea, vomiting, diarrhea, runny nose, severe sweating
Bethanechol chloride (Urecholine®)	Agonist at preganglionic cholinergic parasympathetic nervous system	10 mg–50 mg TID/QID	Gastrointestinal upset, sweating, miosis
Pilocarpine (Salagen®)	Agonist at muscarinic acetylcholine receptors M_1, M_2, and M_3	3 mg–5 mg TID	Sweating, nausea, dizziness, increased pulmonary secretions
Anethole trithione (Sialor®)	Upregulates the number of muscarinic receptor sites on the salivary acinar cells	25 mg TID	Gastrointestinal upset, flatulence, abdominal pain

osteonecrosis of the jaw.[39] The clients in those reports showed signs similar to medication-related osteonecrosis of the jaw in the extraction sockets. The literature reports no evidence of methamphetamine's effect on bone remodeling, but current hypotheses point to methamphetamine's effect on soft tissues and vascularization[40] or the effect of inhaled toxic vapours from the methamphetamine manufacturing process[41] on the healing socket.

The practitioner should recognize that the client's drug seeking behaviour may leave little concern for self-care. Due to the social and financial challenges experienced by this population, it is likely that their diet, caries prevalence, and oral hygiene will contribute to a high caries risk. Methamphetamine suppresses the appetite and the individual is less likely to have a regular meal schedule. Sugar cravings have been shown to be associated with methamphetamine addiction; clients who use methamphetamine report a higher frequency of carbohydrate snacking and sugary, carbonated drink consumption.[30] Expect these clients to have low motivation for oral hygiene practices.[21] A thorough caries risk assessment (CRA) and dietary record should be taken to evaluate and address deficiencies contributing to the client's poor oral health. An intense preventive regimen should be initiated for these clients. All scaling should be followed by oral hygiene instruction and motivation with continuous reinforcement at future recalls.

A diagnosis of xerostomia can be made from a client concern and a clinical examination along with a history taking. Client complaints and clinical examinations may reveal a wide range of symptoms to varying degrees (Table 3). A salivary flow test (SFT) can also be conducted, which measures both resting and stimulated salivary flow rates. Table 3 outlines the procedure of the SFT, which can be administered chairside. Table 4 shows the current recommended preventive protocol for individuals with high and extremely high caries risk.

Management of xerostomia

As the most significant etiological factor leading to the deterioration of oral health in cocaine and methamphetamine users, xerostomia should be appropriately managed. For the client experiencing mild symptoms a conservative approach can be tried first. In the recovering cocaine or methamphetamine user, the xerostomia may improve with the equilibration of their CNS. To facilitate salivary function, an increased intake of water, a decrease in alcohol consumption, and a reduction of other xerostomia-inducing medications should be considered as these are the most important factors for the management of xerostomia.[43]

Symptomatic relief through topical agents can help to reduce the discomfort associated with xerostomia. Local salivary stimulants such as sugar-free gum, adhesive discs, and vitamin C also work to reduce xerostomia. It should be noted that local measures have a varying degree of therapeutic success and are largely dependent on the client's subjective sensation.[43]

When non-pharmacological treatments are insufficient, or for moderate to severe xerostomia, pharmaceuticals can be considered. Systemic salivary stimulators, termed sialagogues, increase salivary secretions through synaptic stimulation of acinar cells within the salivary glands. A good pharmacological choice for the management of xerostomia in the client with a substance use disorder is Cevimeline. Cevimeline has the narrowest range of action and, as a result, has the least severe adverse effects. Its high affinity for the muscarinic M_1 and M_3 receptors and low affinity for M_2 and M_4 receptors facilitates this. By avoiding the stimulation of the M_2 and M_4 receptors, Cevimeline has a negligible effect on cardiac and lung tissues. Cevimeline should be strongly considered for clients with pulmonary or cardiac dysfunction.[44] Table 5 describes other common pharmacological treatments for xerostomia.

CONCLUSION

Dental practitioners have a duty to their clients to learn and understand the principles underlying their diseases in order to provide the most effective care possible. Substance use disorders are common enough that clinicians need to be familiar with best practices for the dental management of these clients. A clinical evaluation and candid talk with the client are usually sufficient for a preliminary diagnosis. A positive note for these clients is that the oral destruction that accompanies methamphetamine and cocaine use can be halted with the cessation of the drug use. Because clients with a substance use disorder often experience severe tooth pain and loss of function, dental professionals may be the first health care provider to evaluate them. Through medical consultation and referrals to community resources, dental professionals may be the initiating factor that leads to client recovery.

Although the client may present with quite severe destruction in the oral cavity, their oral conditions are not unique and are manageable. Dental professionals have the means to treat rampant caries, periodontal disease, and xerostomia—the findings associated with "meth mouth." The treatment prognosis should be heavily guarded, and the client should be informed of the likely failure and continued destruction of the oral cavity if the addiction is not managed. As a significant contributor to oral disease in these clients, xerostomia requires special attention during treatment. With drug cessation and following current best practices including effective pharmacological care, oral rehabilitation of these clients is possible.

CONFLICTS OF INTEREST

The authors have declared no conflicts of interest.

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