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The skinny on weight-loss medications and oral health

An evaluation of Ozempic, Mounjaro, Wegovy, and other GLP-1 and GIP medications for dental health-care professionals

A PEER-REVIEWED ARTICLE | by Mia L. Geisinger, DDS, MS

ABSTRACT

An increasing number of people are using glucagon-like peptide receptor agonists (GLP-1-RA) and glucose-dependent insulinotropic polypeptide receptor agonist (GIPR) medications for both glycemic control and weight loss. These medications are often referred to as "incretin mimetics," and they target physiologic processes that are involved with dysglycemia, nutrient metabolism, and nutrient storage. Given the relative novelty of this drug class, it is important that dental health-care professionals understand their mechanisms of action, common side effects, and impacts on oral and overall health. This course will review the functions of GLP-1-RA and GIPR medications, their intended and side effects, and the clinical implications for care in the dental setting.

EDUCATIONAL OBJECTIVES

Upon completion of this course, the dental professional should be able to:

1. Describe the mechanisms of action and rationale for use of GLP-1-RA and GIPR medications
2. Critically evaluate side effects of GLP-1RA and GIPR medications and their implications for dental health-care professionals
3. Evaluate the impact of GLP-1RA and GIPR medications on oral health, including xerostomia, halitosis, and periodontal disease
4. Understand the clinical implications for patients seeking dental care who are taking GLP-1-RA and GIPR medications

Believe it or not, the first generation of the types of medications that sparked the current weight-loss medication boom was based upon evaluation of saliva from the venomous North American lizard, the Gila monster! In the 1990s, researchers discovered that venom present in the saliva of the Gila monster contained an enzyme called exendin-4, which stimulates insulin production.[1] The FDA approved a synthetic version of exendin-4, exenatide, for medical treatment of diabetes mellitus in 2005.[2] This drug was marketed under the brand names Byetta and Bydureon. Previous investigations had demonstrated that hormones from the gut contributed to the insulin secretion in response to meals.[3] This was often referred to

as the "incretin concept." Glucagon-like peptide 1 (GLP-1) was identified as an important "incretin" hormone. GLP-1 not only increases insulin secretion but increases β-cell proliferation and survival, suppresses glucagon secretion, delays gastric emptying, and suppresses appetite—all of these actions contributing to a potential antidiabetic effect.[3] However, GLP-1 has a very short half-life due to its rapid breakdown by dipeptidyl peptidase IV and ectopeptidases, so a peptide-like exendin-4 could mimic GLP-1 through stimulating the GLP-1 receptor.[3] Additional GLP-1 receptor agonists (GLP-1-RA) were developed to treat type 2 diabetes mellitus and weight loss.[4] These drugs are also currently being studied as potential therapeutics for peripheral artery disease, diabetic kidney disease, metabolic liver disorders, and neurodegenerative disorders.[5]

The first second-generation GLP-1-RA medications were approved by the US Food and Drug Administration (FDA) for diabetes management in 2010.[6] It has been estimated that currently up to 6% of the US population is taking GLP-1-RA medications; these numbers may be poised to increase as the indications for the use of GLP-1-RA medications are expanded to include other common conditions such as heart disease and dementia.[7-9] Most adults who have taken GLP-1RA drugs say they took them to treat a chronic condition including diabetes or heart disease (62%), whereas approximately 40% state that they took the medications primarily to lose weight.[9] Further, GLP-1-RA users are disproportionately female (59.6%) and just under two-thirds (63.5%) had a body mass index (BMI) of 30 kg/m^2 or greater.[6] Notably, not all patients using GLP-1-RA medications were considered obese, with 13.7% of patients having a BMI of 25 to 29.9, and 4.2% having a BMI of 24.9 or under.[6] An additional 162,023 people (18.6% of users) did not have their BMI recorded.[6]

TABLE 1: Mechanisms of action of incretin hormones

	GIPR	GLP-1
Source	Released from intestinal K-cells in the duodenum and jejunum	Secreted from intestinal L-cells in the distal ileum and colon
Actions	Promotes bone formation, fat deposition, and glucagon response	Inhibits bone absorption, gut inflammation, and suppresses glucagon response

An additional class of weight-loss medications with growing popularity are the glucose-dependent insulinotropic polypeptide receptor agonists (GIPR). GIP is naturally produced by the enteroendocrine K cells in the proximal intestine and secreted into the bloodstream in response to the ingestion of nutrients.[10] The mechanisms of action of GIP receptor agonists include stimulation of insulin production, inducing increased insulin sensitivity, reduction of stomach acid secretion, decreasing the amount of glucose made by the liver, and delayed digestion. In practical clinical applications, GIPR medications can be used in combination with GLP-1-RA medications to enhance the efficiency of GLP-1-RA medications for diabetes control and weight loss.[11] The combination of GIP receptor agonists and GLP-1-RA medications is often referred to as "dual agonists."[11,12] Tirzepatide (Mounjaro) is a dual GLP-1/GIPR that has recently been licensed for type 2 diabetes in the US.[12,13] Table 1 demonstrates the differences in origin and action of GLP-1 and GIP hormones and reflects the complementary mechanisms of action.

Given the commonplace use of novel weight-loss medications for a variety of conditions, it is critical that dental health-care professionals understand the potential impacts of these medications on oral health and the considerations for the provision of dental care to individuals taking these medications.

Formulations and indications for use of novel weight-loss medications

The current FDA-approved incretin mimetic medications and their approved indications are summarized in Table 2.

GLP-1 receptor agonist drugs: GLP-1-RA medications have been approved by the FDA to treat type 2 diabetes mellitus and, in some instances, for weight loss. These medications work by mimicking a hormone that helps control insulin and blood glucose levels and promotes feelings of satiety. Some examples of GLP-1-RA medications include[14]:

- Dulaglutide (Trulicity): weekly injection
- Exenatide (Byetta): twice-daily injection
- Exenatide extended release (Bydureon Bcise): weekly injection
- Liraglutide (Victoza, Saxenda): daily injection
- Lixisenatide (Adlyxin): daily injection
- Semaglutide (Ozempic): weekly injection
- Semaglutide (Rybelsus): tablet taken once daily

All of the listed GLP-1-RA medications have been approved for improvement of glycemic control in patients with type 2 diabetes mellitus.[15] The FDA currently approves the use of semaglutide and high-dose liraglutide to help treat obesity defined as a BMI of greater than or equal to 30 kg/m^2.[16] Both of these medications (semaglutide and liraglutide) are also approved for weight loss in individuals who are considered overweight (25–29.9 kg/m^2) with at least

TABLE 2: FDA-approved GLP-1-RA and GIPR/GLP-1-RA medications

Trade name	Generic name	Medication type	Population (indication)	Approval year
Byetta	Exanitide	GLP-1-RA	Type 2 diabetes	2005
Victoza	Liraglutide	GLP-1-RA	Type 2 diabetes	2010
Trulicity	Dulaglutide	GLP-1-RA	Type 2 diabetes	2014
Saxenda	Liraglutide	GLP-1-RA	Obesity/overweight	2014
Adlyxin	Lixisenatide	GLP-1-RA	Type 2 diabetes	2016
Xultophy	Liraglutide + insulin degludec	GLP-1-RA + basal insulin	Type 2 diabetes	2016
Soliqua	Lixisenatide + insulin glargine	GLP-1-RA + basal insulin	Type 2 diabetes	2016
Bydureon BCise	Exenatide	GLP-1-RA	Type 2 diabetes	2017
Ozempic	Semaglutide	GLP-1-RA	Type 2 diabetes	2017
Rybelsus	Semaglutide	GLP-1-RA	Type 2 diabetes	2019
Wegovy	Semaglutide	GLP-1-RA	Obesity/overweight	2021
Mounjaro	Tirzepatide	GLP-1/GIPR	Type 2 diabetes	2022
Zepbound	Tirzepatide	GLP-1/GIPR	Obesity/overweight	2023

one weight-related health condition.[9] Semaglutide has been approved to help reduce the risk of major cardiovascular adverse events in patients with type 2 diabetes and established cardiovascular disease.[17] The FDA has also approved a treatment to reduce the risk of serious heart problems in adults who are overweight or obese.[17] It should also be noted that GLP-1 drugs are also being prescribed off-label based upon anecdotal evidence to treat alcohol use and other substance-use disorders, nonalcoholic fatty liver disease (NAFLD), chronic kidney disease without albuminuria, Parkinson's disease, Alzheimer's disease, and osteoarthritis, but such uses are not FDA-approved.[18,19]

GIPR/GLP-1-RA drugs: The FDA has approved two medications that contain the active ingredient tirzepatide and target the glucose-dependent insulinotropic polypeptide (GIP) receptor.[20,21] The tirzepatide-containing medications that are currently FDA-approved in the US, Mounjaro and Zepbound, are dual agonists (or "twincretins") that exert complementary actions, and these medications are more potent than pure GLP-1-RA medications.[22] Research has demonstrated GIPR/GLP-1-RA dual agonists result in significantly greater body weight reduction compared to GLP-1-RA single agonists in overweight and obese persons.[23] Further, simultaneous activation of GLP-1-RA and GIPR could have a multiplicative effect on dysglycemia. The insulinotropic action of GIP hormone is blunted in individuals with severe hyperglycemia, in contrast to the intact action of GLP-1.[24] These medications may be used as a second-line treatment option for individuals who demonstrate suboptimal results on other medications for type 2 diabetes mellitus.

GLP-1-RA medications are often prescribed when first-line oral hypoglycemic medications alone are not enough to control blood sugar levels.[16] Some patients may also need to take less of their other diabetes medications while taking GLP-1 receptor agonists.[16] Individuals taking GLP-1 medications lost an average of 10%–20% of their body weight during a 12-month course of treatment.[25] Tirzepatide-containing medications demonstrate dose-dependent weight loss over a 72-week course, ranging between 15% and 30%.[26]

Weight-loss medication mechanisms of action and pharmacology

GLP-1-RA and GIPR medications mimic naturally occurring hormones called "incretins." These endogenous hormones regulate energy homeostasis and glucose levels. Both incretins have hormonal effects on multiple organs, in particular the pancreas, the gut, and the brain.[27] The predominant role of these hormones is regulation of energy homeostasis. They stimulate insulin secretion in a glucose-dependent manner, delay gastric emptying, and suppress appetite.[27] This combination of effects makes a significant contribution to glucose homeostasis, particularly the control of postprandial glucose.[27] Subsequent studies have identified other actions including improvement in pancreatic β-cell glucose sensitivity and, in animal studies, promotion of pancreatic β-cell proliferation and reduction in β-cell apoptosis.[27] Further, these hormones seem to work in tandem; GLP-1 inhibits glucagon secretion when plasma glucose concentration is high, while GIP acts to lower glucose levels.[28] GIP essentially functions as both an ally and a rival to GLP-1 in type 2 diabetes mellitus, depending upon the glucose status, the stage in the natural history of the disease, and the degree of GLP-1 presence in the system.[28] In a paradoxical fashion, postprandial hyperglucagonemia—a common finding in type 2 diabetes mellitus—contributes to glucose fluctuations in the fed state.[29] Glucagon's stimulatory effect

on endogenous hepatic glucose production is a prime culprit in glucose elevations after meals. Glucagon regulates energy homeostasis and body weight as a counter-regulatory hormone to insulin. Incretin hormones are known to modulate pancreatic alpha cell glucagon secretion. GLP-1 generally suppresses glucagon secretion at higher serum glucose levels, whereas GIP stimulates glucagon secretion at lower serum glucose levels. Pharmacological dual incretin receptor agonist therapies utilize effects on glucagon secretion that are of clinical importance in antidiabetic regimens.[30]

Incretin mimetic medications, such as GLP-1-RA and GIPR, are generally injection medications with the exception of newly developed oral semaglutide medications.[29] For injection incretin medications, subcutaneous administration allows for rapid absorption and peak concentrations within hours. Incretin mimetics have a low volume of distribution and remain mostly in the bloodstream.[31] Metabolism of various GLP-1-RA medications differs with the different formulations.[32,33] For example, exenatide is metabolized in the kidneys and liver through hydrolysis, which produces smaller, inactive peptides that are excreted in the urine, whereas liraglutide is metabolized through proteolytic cleavage in various tissues.[30,31] The most common GLP-1-RA medication, semaglutide, is metabolized into individual amino acids by serum and tissue proteases.[32,33] The peptide structure of tirzepatide (GLP-1/GIPR) is metabolized through proteolytic cleavage, whereas the fatty acid component undergoes b-oxidation and amide hydrolysis.[21] The kidneys are the primary organ responsible for clearing incretin mimetic medications from the body.[31] Figure 1 demonstrates the direct and indirect actions of GLP-1-RA and GIPR medications.

Oral semaglutide (Rybelsus) is recommended to be taken in a fasting state at least 30 minutes prior to ingesting food, drink, or other oral medications.[34] Food intake following medication ingestion and various dosing conditions including water volume and dosing schedules can affect the oral semaglutide pharmacokinetics.[35] Patients taking oral semaglutide generally achieve therapeutic levels approximately 13 days after their initial dose, and patients achieve steady state drug levels after this time period.[36]

Common weight-loss medication side effects

GLP-1-RA and GIPR medications can have a number of side effects that impact patients to varying degrees. Approximately one-quarter of patients taking these medications discontinue within the first three months, and more than one-third discontinue within a year.[37] Unwanted side effects, particularly gastrointestinal effects, are a frequent reason that patients cite for stopping the medications.[37] The most common side effects are nausea and vomiting.[38] Other frequently recorded side effects are

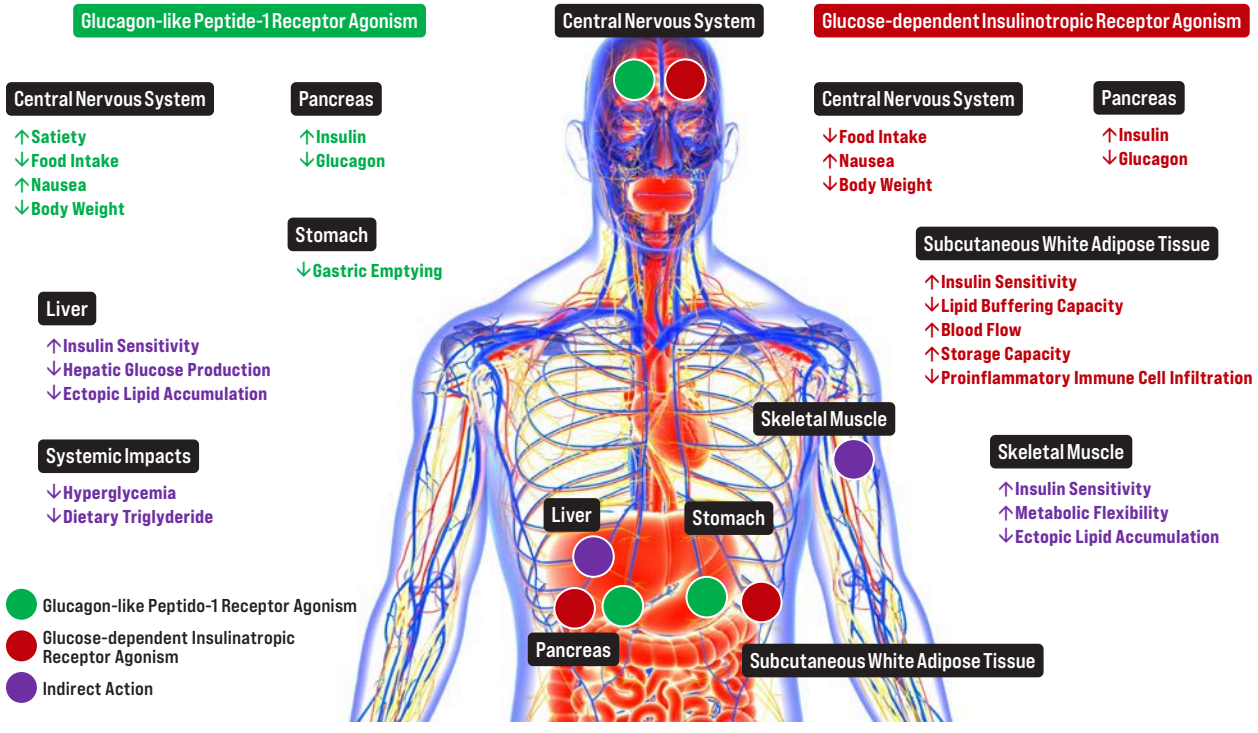

FIGURE 1: Direct and indirect mechanisms of action of novel weight-loss medications

diarrhea, constipation, headaches, indigestion, dizziness, and mild tachycardia (increased heart rate).[38] These side effects may be time- and dose-dependent, with most patients reporting the greatest frequency and severity of such common side effects in the initial four weeks after beginning weight-loss medications.[39] Other side effects that are generally transient may include injection site reactions, nasopharyngitis, and temporary itchiness or redness at the injection site.[16] More serious side effects include pancreatitis, gastroparesis, bowel obstruction, gallstone attacks, and bile duct blockage.[38] While these side effects are less common, some cause significant morbidity and/or mortality and may be irreversible. It is recommended that patients taking these medications seek immediate medical attention if they experience severe vomiting and/or diarrhea, severe pain or tenderness in their abdominal area, lack of bowel movements and/or the lack of flatulence, or jaundice.[14,16] Some outlets have also reported patient complaints related to "Ozempic face," which has been described as an aged and hollowed look to the face.[38] This appearance has been associated with rapid weight loss and can be associated with any of the incretin mimetic medications.[38] Other symptoms of "Ozempic face" include changes in the size of the lips, cheeks, and chin, increased wrinkles on the face, sunken eyes, and sagging jowls around the jaw and neck.[38] Patients who demonstrate rapid weight loss and/or changes in their appearance should be questioned to determine if they are losing weight purposefully and any medications they may be taking to assist their weight-loss journey.

It should also be noted that the high marketplace demand for incretin mimetic medications has resulted in drug shortages. Such shortages may make accessing medications challenging for patients seeking treatment for dysglycemia and weight loss.[40] These shortages have led to patients seeking access to these medications through online companies or compounding pharmacies.[40] While it is legal for compounding pharmacies to produce GLP-1 drugs during times of shortage, the products are not reviewed for safety or efficacy by the FDA.[40] It has been reported that compounding pharmacies may use salt forms of semaglutide that differ from the FDA-approved active ingredient in approved semaglutide products.[41] There have also been reports of counterfeit, illegally manufactured semaglutide medications entering the US marketplace.[42] These counterfeit medications have higher rates of contamination with undeclared active ingredients.[42] As of August 31, 2024, poison control centers have managed 5,401 GLP-1 agonist-related exposure cases, and most of these are associated with accidental therapeutic errors in dosing FDA-approved GLP-1-RA medications.[40] Such errors may include taking doses too close together or taking a higher than recommended dose at one time.[40] When patients are using compounded products, the injections that they are delivering are via a syringe versus a set-dose injection pen. Patients using compounded medications have reported accidentally taking up to tenfold the recommended dose due to patient error reading the measurement units on the syringe.[40]

Potential impacts of weight-loss medication on oral health

The oral impacts of GLP-1-RA and GIPR medications have been thrust into the spotlight recently after the makers of Ozempic and Mounjaro, Novo Nordisk and Eli Lilly and Company, respectively, were sued in the US District Court in the Western District of Louisiana by a plaintiff, Jaclyn Bjorklund, who stated that she suffered vomiting so severe that it caused her to lose teeth.[43] While this outcome may be extreme, oral symptoms with potentially long-term serious consequences have been noted in individuals prescribed GLP-1-RA and/or GIPR medications.[44-47]

Halitosis: Because these novel weight-loss medications result in delayed gastric emptying, their use has been associated with increased incidence of halitosis as a result of increased reflux of digestive products or increased volatile sulfur compounds related to gases in the stomach being released.[45] The use of these medications has also been related to an increase in a ketotic metabolic state when fat is utilized for energy rather than protein and/or carbohydrates. The ketones that are released into the breath can smell fruity, like acetone, and may also be associated with a metallic taste.[45-47]

Xerostomia: Patient-reported oral dryness and minimal, ropy salivary flow has been associated with the use of semaglutide.[48] This xerostomia and hyposalivation was relieved with discontinuation of GLP-1-RA medications. It is estimated that patients generally experience approximately a 50% reduction in salivary flow before oral dryness is clinically detectable.[49,50] Xerostomia can increase the risk for dental caries and periodontal disease.[51] Adequate salivary flow is associated with decreased plaque accumulation and higher intraoral pH.[51] Patients may commonly have dental caries (especially root, cervical, or incisal/cuspal tips), plaque accumulation, gingivitis, and/or periodontitis.[51,52] Because of this, individuals taking novel weight-loss medications may demonstrate signs of xerostomia, including[51]:

- Patient-reported sticky, dry, or burning feelings in the mouth

- Difficulty chewing, swallowing, tasting, or speaking, including hoarseness
- Altered taste or intolerance for spicy, salty, or sour foods or drinks
- Dry or sore throat
- Cracked, peeling, chapped, or atrophic lips and/or perioral tissues
- Dry and/or rough sensations on the tongue
- Intraoral ulcers
- Oral fungal infection (e.g., candidiasis)
- Halitosis
- Pain upon utilization or inability to retain removable prostheses

Gingivitis and periodontitis: Both gingivitis and periodontitis can be exacerbated by oral dryness.[53,54] This may occur through the direct effect of reduced salivary flow, resulting in increased plaque biofilm accumulation and increased gingival inflammation. Xerostomia and subsequent discomfort associated with oral dryness in the tissues can reduce the frequency and quality of home care and potentially cause patients to avoid using dentifrices, mouthrinses, or other cleaning aids.[55] This lack of biofilm disruption may cause increased dysbiosis and more severe periodontal inflammation.

Taste alterations: GLP-1-RA medications have been reported to alter taste sensations in some patients, also known as dysgeusia. Research has demonstrated that in women with obesity, the intensity of perceived sweet taste is improved when patients are taking weight-loss drugs.[56,57] This may result in aversion to sweetness and a need to alter oral care products.[56,57] Patients also demonstrated regeneration of lingual taste buds and changes in gene expression related to taste after taking these medications.[56,57] Patients have reported an increase in bitter taste sensation, particularly associated with certain foods such as coffee, dark chocolate, or green leafy vegetables.[58,59] They have also reported increased salty and metallic tastes that interfere with eating and could impact oral health.[56,58]

Clinical considerations in dentistry for patients taking novel weight-loss medications

It is critical that dental health-care professionals understand the underlying mechanisms of action and implications for the delivery of dental care for patients taking incretin mimetic medications. A thorough medical history to include a review of anthropomorphic measurements, physical activity levels, and current/past medication usage is a critical component of all dental evaluations. Any patient-reported symptoms such as nausea and vomiting, gastrointestinal distress, and/or rapid weight loss should be further assessed to determine the underlying cause and implications for oral and overall health. Due to the increased risks of xerostomia, patients taking this class of medications should be considered at increased risk of both caries and periodontal disease. Assessment of salivary flow and perceived oral dryness as well as implementation of protocols to mitigate these risks, including encouraging adequate hydration, emphasis on meticulous oral hygiene delivery including brushing and interdental cleaning, increasing the frequency of dental examinations and cleanings, and/or recommendation for the use of high-fluoride dentifrice should be implemented, as indicated by the overall dental conditions and thorough risk assessments.[44]

Dental health-care professionals should also be aware of increased risks of medical emergencies in patients taking these medications.[60] Serious allergic reactions are rare, but have been reported, including swelling of the face, lips, tongue, and throat.[60] Any evidence of hypersensitivity reaction should be treated as a medical emergency and emergent care should be delivered immediately. In the case of anaphylaxis, immediate administration of epinephrine (1:1000 concentration) is warranted. In addition, patients who are taking these medications have an increased likelihood of hypoglycemic episodes due to the lowering of overall serum glucose levels.[14] Early signs of hypoglycemia include pallor, diaphoresis, headache, hunger, nausea, irregular and/or rapid heart rate, weakness, dizziness, and tingling or numbness in the lips, tongue, or cheek.[14] As hypoglycemia progresses, patients may experience loss of coordination, slurred speech, blurry vision, agitation, and severe confusion. If patients exhibit any of these symptoms, casual blood glucose should be assessed using a glucometer, and emergency protocols should be instituted if blood glucose levels are below 70 mg/dL or if symptoms persist after initial evaluation.[14] In patients who are conscious, oral delivery of simple carbohydrates (e.g., sugared beverages, glucose tablets) can be consumed. If patients become unresponsive, sublingual glucose gel and/or intravenous delivery of dextrose and/or glucose solution should be delivered.

Incretin mimetic medications delay gastric emptying, which may be ameliorated with long-term use. Given the increased digestive transit time in patients using these medications, there are concerns that GLP-1-RA and GIPR medications can increase the risk of regurgitation and pulmonary aspiration of gastric contents during sedation procedures. It has also been reported that the frequency and presence of gastrointestinal symptoms, including nausea, vomiting, dyspepsia, and abdominal distention, are predictive of increased residual gastric contents.[61] A consortium of surgical and anesthesiology societies, including the American Society of

Anesthesiologists (ASA), developed updated guidance in November 2024 regarding perioperative care for individuals taking GLP-1RA medications seeking elective surgical procedures with sedation and/or general anesthesia.[61]

Considerations regarding increased risk for delayed gastric emptying: Health-care professionals should consider the following variables as elevating the risk of delayed gastric emptying and aspiration with the periprocedural use of GLP-1RA:[61]

- The escalation phase, versus the maintenance phase, is associated with a higher risk of delayed gastric emptying with GLP-1RA usage.
- The higher the dose of GLP-1RA, the more likely the risk of gastrointestinal side effects.
- Gastrointestinal side effects are more common with weekly compared to daily formulation compounds.
- Symptoms suggestive of delayed gastric emptying and intestinal transit times may include nausea, vomiting, abdominal pain, dyspepsia, and constipation.
- Patients taking GLP-1RA should be evaluated for other medical conditions that may exacerbate gastrointestinal symptoms and delay gastric emptying—such as but not limited to—bowel dysmotility, gastroparesis, and Parkinson's disease.

Perioperative management

- Dental health-care professionals should investigate preoperative gastrointestinal symptoms, such as severe nausea/vomiting, abdominal bloating, or abdominal pain. If these are present, consider delaying the procedure to reduce risks of regurgitation and pulmonary aspiration of gastric contents.
- GLP-1RA therapy may be continued preoperatively in patients without elevated risk of delayed gastric emptying and aspiration.
- If the risks associated with delayed gastric emptying outweigh the benefits to glycemic control and weight loss, it is recommended that patients consume only a clear liquid diet for 24 hours prior to the fasting period associated with their sedation or general anesthesia procedure.
- If, in consultation with the managing physician, it is determined advisable to hold GLP-1RA medications, the dose prior to the surgical procedure (either the day prior for daily dosing or the week prior for weekly dosing) should be held.[61]

Comprehensive presedation assessments of patients taking GLP-1-RA medications should include a complete review of symptoms and perioperative risk assessment.[61]

Conclusion

GLP-1-RA and GIPR are novel medications that impact the nutrient metabolism, central hunger cues, endocrinological function, and gastrointestinal function. Given the significant growth in the prescription of these medications, it is likely that dental health-care professionals will be frequently called on to provide oral health care to patients who are taking these medications. Familiarity with the mechanisms of action, desired and adverse effects, and potential oral implications of these medications is critical to allow dental health-care professionals to deliver safe and effective care for patients using them. Comprehensive oral evaluation, risk assessment, and review of relevant medical and dental histories, including all medications, and collaboration with treating medical professionals should be considered. It should also be noted that new research is emerging and it is imperative that dental health-care professionals stay abreast of new findings related to dental health-care delivery.

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1. The initial GLP-1-RA medications were developed based upon the action of the venom from which animal?
   - A. Black mamba snake
   - B. Gila monster
   - C. Eastern diamondback snake
   - D. Box jellyfish

2. When was the first GLP-1 medication approved by the US Food and Drug Administration?
   - A. 2005
   - B. 2012
   - C. 2018
   - D. 2022

3. Which of the following are considered incretin hormones?
   - A. Glucagon-like peptide
   - B. Insulin
   - C. Glucose-dependent insulinotropic polypeptide
   - D. A and C

4. Which of the following is not currently identified as a potential condition that may be treated by incretin-mimetic medications?
   - A. Diabetic kidney disease
   - B. Peripheral artery disease
   - C. Rheumatoid arthritis
   - D. Neurodegenerative disorders

5. It has been estimated that up to ___% of the US population is currently taking GLP-1-RA medications.
   - A. 1
   - B. 3
   - C. 6
   - D. 10

6. Approximately ___% of patients taking GLP-1-RA medications report they are taking the medications primarily to lose weight.
   - A. 10
   - B. 20
   - C. 40
   - D. 60

7. What is the source from which the glucose-dependent insulinotropic polypeptides are secreted naturally?
   - A. Pancreatic b-islet cells
   - B. Ileum and colon L-cells
   - C. Central nervous system
   - D. Duodenum and jejunum K-cells

8. The US Food and Drug Administration currently approves incretin mimetic medications for weight loss in which of the following clinical conditions?
   - A. Class III obesity defined as BMI ³ 40 kg/m^2
   - B. Class II obesity defined as BMI ³ 35 kg/m^2
   - C. Obesity defined as BMI ³ 30 kg/m^2
   - D. Overweight defined as BMI 25-29.9 kg/m^2 without other weight-related chronic conditions

9. Individuals taking GLP-1 medications lost an average of 10%–20% of their body weight during a 12-month course of treatment. Tirzepatide-containing medications demonstrate dose-dependent weight loss over a 72-week course, ranging between 15%–30%.
   - A. Both statements are true.
   - B. The first statement is true; the second statement is false.
   - C. The first statement is false; the second statement is true.
   - D. Both statements are false.

10. Which of the following is not a mechanism of action of GLP-1-RA medications?
   - A. Decreased food intake
   - B. Decreased insulin production
   - C. Delayed gastric emptying
   - D. Decreased glucagon production

11. It is recommended that oral semaglutide is taken in a fasting state at least ___ minutes prior to ingesting food, drink, or other oral medications.
   - A. 15
   - B. 30
   - C. 60
   - D. 90

12. Approximately ___% of patients taking incretin mimetic medications discontinue the medications within the first three months.
   - A. 5
   - B. 10
   - C. 25
   - D. 50

13. Which is/are the most common side effect(s) of incretin mimetic medications?
   - A. Nausea and vomiting
   - B. Gastroparesis
   - C. Pancreatitis
   - D. Injection site reactions

14. Compounding of GLP-1-RA medications is allowed in times of shortages, but one drawback to the use of compounded medications may be increased incidence of accidental overdose of these medications. Patients using compounded medications have reported accidentally taking up to fivefold the recommended dose due to patient error reading measurement units on the syringe.
   - A. Both statements are true.
   - B. The first statement is true; the second statement is false.
   - C. The first statement is false; the second statement is true.
   - D. Both statements are false.

15. Which of the following is not a potential impact of incretin mimetic medications on oral health?
   - A. Halitosis
   - B. Xerostomia
   - C. Taste alterations
   - D. Increased oral cancer risk

16. It is estimated that patients generally experience approximately a ___% reduction in salivary flow before oral dryness is clinically detectable.
   - A. 15
   - B. 30
   - C. 50
   - D. 70

17. Which of the following is not a sign/symptom of xerostomia?
   - A. Difficulty chewing, swallowing, tasting, or speaking (including hoarseness)
   - B. Dry and/or rough sensations on the tongue
   - C. Oral fungal infections
   - D. Increased retention of removable prostheses

18. Patients taking incretin mimetic medications demonstrate ___ of taste buds and changes in gene expression related to taste.
   - A. Destruction
   - B. Regeneration
   - C. Anterior to posterior shift
   - D. Posterior to anterior shift

19. Given the risk of xerostomia in patients taking incretin mimetics, dental health-care professionals should perform an assessment of salivary flow and perceived oral dryness. The implementation of protocols to mitigate increased risk of caries and periodontal disease should include: emphasis on meticulous oral hygiene delivery and/or the use of high-fluoride dentifrice.
   - A. Both statements are true.
   - B. The first statement is true; the second statement is false.
   - C. The first statement is false; the second statement is true.
   - D. Both statement is false.

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20. Which of the following is not an early sign of hypoglycemia?

A. Diaphoresis

B. Headache

C. Increased visual acuity

D. Tingling or numbness in the lips, tongue, or cheek

21. Late signs of hypoglycemia can be identified by signs and symptoms including loss of coordination, slurred speech, blurry vision, agitation, and severe confusion. If patients taking incretin mimetic medications experience these symptoms, what test should be performed next?

A. Blood pressure

B. Pulse rate

C. Casual blood glucose

D. Pulse oximetry

22. Emergency protocols should be instituted for patients taking incretin mimetic medications if blood glucose levels are below ___ mg/dL or if patients are symptomatic.

A. 50 B. 70 C. 90 D. 110

23. GLP-1-RA and GIPR medications delay gastric emptying and this can increase the risk of ___ in patients who are undergoing sedation for dental procedures.

A. Regurgitation and pulmonary aspiration

B. Perioperative nausea

C. Intraoperative awareness

D. Increased medication need during sedation

24. The frequency and presence of ___ is/are predictive of increased residual gastric contents.

A. Gastrointestinal symptoms

B. Xerostomia

C. Hypoglycemia

D. Decreased appetite

25. Which of the following is not an indicator of increased risk of delayed gastric emptying in patients taking GLP-1RA medications?

A. Patients in the escalation phase of GLP-1RA medications

B. Patients taking higher doses of GLP-1RA medications

C. Patients who demonstrate nausea and vomiting

D. Patients who have been on GLP-1RA medications for > 6 months

26. If the risks associated with delayed gastric emptying outweigh the benefits to glycemic control and weight loss, it is recommended that patients consume only a clear liquid diet for ___ hours prior to the fasting period associated with their sedation or general anesthesia procedure.

A. 6 B. 12 C. 24 D. 48

27. Dental health-care professionals should investigate preoperative gastrointestinal symptoms, such as severe nausea/vomiting, abdominal bloating, or abdominal pain.

A. If these are present, consider delaying the procedure to reduce risk of regurgitation and pulmonary aspiration of gastric contents.

B. Both statements are true.

C. The first statement is true; the second statement is false.

D. The first statement is false; the second statement is true.

28. Both statements are false.

A. For patients at low risk for delayed gastric emptying associated with GLP-1-RA drugs, it is recommended that preoperative fasting should be:

B. Increased

C. Unchanged

D. Decreased

29. Altered based upon the carbohydrate content of the last year

A. Which of the following medications promotes fat deposition?

B. GLP-1-RA

C. GIPR

D. Insulin

30. Biguanides

A. Which of the following is not an indirect impact of GLP-1-RA and GIPR medications on the liver?

B. Increased insulin sensitivity

C. Decreased hepatic glucose production

D. Increased glycogen production

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1. Describe the mechanisms of action and rationale for use of GLP-1-RA and GIPR medications
2. Critically evaluate side effects of GLP-1RA and GIPR medications and their implications for dental health-care professionals
3. Evaluate the impact of GLP-1RA and GIPR medications on oral health, including xerostomia, halitosis, and periodontal disease
4. Understand the clinical implications for patients seeking dental care who are taking GLP-1-RA and GIPR medications

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15.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	30.	Ⓐ	Ⓑ	Ⓒ	Ⓓ

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EXAM INSTRUCTIONS. All questions have only one answer. If mailed or faxed, grading of this examination is done manually. Participants will receive confirmation of passing by receipt of a Verification of Participation form. The form will be mailed within two weeks after receipt of an examination.

COURSE EVALUATION AND FEEDBACK. We encourage participant feedback. Complete the evaluation above and e-mail additional feedback to Rachel McIntyre (rmcintyre@endeavorb2b.com) and Laura Winfield-Roy (lwinfield@endeavorb2b.com).

COURSE CREDITS AND COST. All participants scoring 70% or higher on the examination will receive a verification form for three (3) continuing education (CE) credits. Participants are urged to contact their state dental boards for CE requirements. The cost for courses ranges from $20 to $110.

CANCELLATION AND REFUND POLICY. Participants who are not 100% satisfied can request a refund by contacting Endeavor Business Media in writing.

RECORD KEEPING Endeavor Business Media maintains records of your successful completion of any exam for a minimum of six years. Please contact our offices for a copy of your CE credits report. This report, which will list all credits earned to date, will be generated and mailed to you within five business days of receipt.

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