Episode 94 – Diabetes: Part 3 – Oral Health October 13, 2023

Overview

Diabetes is a chronic metabolic disease characterized by hyperglycemia due to deficient insulin secretion, insulin resistance, or both. Type 1 diabetes is an autoimmune disease characterized by deficient or no insulin production. Type 2 diabetes results from ineffective use of insulin and accounts for 90% of all diabetes cases worldwide. Type 2 diabetes is largely preventable and potentially reversible if identified and managed early. Gestational diabetes is hyperglycemia with blood glucose values above normal but below values diagnostic of diabetes. Gestational diabetes develops during pregnancy and usually resolves after delivery. Prediabetes is higher than normal blood glucose levels, but not yet high enough to be diagnosed as type 2 diabetes. Prediabetes can lead to diabetes unless steps are taken to prevent onset. Type 2 diabetes, gestational diabetes, and prediabetes are more common in individuals who are overweight or obese.[1] [1] [2] [3]

Oral complications

Chronic hyperglycemia leads to various complications in the body, including the oral cavity. The degree of glycemic control appears to be a significant factor in the severity and likelihood of oral complications. Chronic oral complications can negatively impact blood glucose control and quality of life, so prevention and management of blood glucose and oral complications is critical. Possible mechanisms related to oral complications include impaired neutrophil function, increased collagenase activity, reduced collagen synthesis, microangiopathy,[2] and neuropathy. [4] [5] [6]

Oral complications of diabetes include:

- Periodontal disease
- Xerostomia
- Parotid salivary gland enlargement
- Dental caries[3]

[1] Refer to Episode 91 for diabetes types, complications, and risk factors; and Episode 93 for diabetes diagnosis, treatment, and prevention of office medical emergencies.
[2] Microangiopathy is damage or disease of small blood vessels.
[3] The World Health Organization (WHO) Model List of Essential Medicines and Model List of Essential Medicines for Children were updated in July 2023 to include fluoride gel, mouthrinse, and varnish because of their effectiveness and safety in dental caries prevention. Resin-based composites for use as dental sealants and filling materials were added for dental caries prevention and treatment, respectively. Essential medicines satisfy population priority healthcare needs and are selected based on disease prevalence, public health relevance, efficacy, safety, and comparative cost-effectiveness. Refer to Episode 87 for initial discussion on the WHO Essential Medicines Lists. [48] [49]

- Periapical lesions
- Tooth loss
- Burning mouth sensation
- Impaired wound healing
- Increased incidence and severity of infections
- Taste dysfunction
- Coated, fissured, or geographic tongue
- Recurrent aphthous stomatitis
- Oral lichen planus
- Oral potentially malignant disorders
- Oral cancer
- Halitosis [4] [7] [8]

Periodontal disease

Periodontal disease and diabetes have a bidirectional relationship that is well documented in research. Periodontitis is defined as the sixth complication of diabetes, since diabetes can promote the progression, extent, and severity of periodontitis. Conversely, periodontitis is a risk factor for worsening glycemic control and may increase the risk for diabetes complications. The degree of glycemic control appears to be an important determinant in this relationship. [1] [4] [6]

Diabetes can decrease salivary flow and increase the amount of glucose in the saliva, leading to more bacterial growth, altered microbiome, and dental plaque build-up. If not properly managed, these issues can lead to periodontal disease. Furthermore, diabetes influences periodontitis initiation and progression by causing hyperinflammatory response, impairing bone repair processes, and producing advanced glycation end products. Periodontal abscess is commonly associated with uncontrolled diabetes. Recurrent or presence of multiple periodontal abscesses may indicate undiagnosed diabetes. [1] [9] [10] [11]

Periodontitis as a local focus of infection can increase the levels of interleukin-6 (IL-6), tumour necrosis factor alpha (TNF-α), and C-reactive protein (CRP), resulting in increased systemic inflammation, which contributes to insulin resistance. [1]

Research on gingivitis has shown participants with and without diabetes react to experimental plaque accumulation with gingival inflammation. However, those with type 1 diabetes develop an earlier and more severe local inflammatory response to a comparable bacterial challenge. [12]

A meta-analysis by Zheng et al. (2021) of 27 studies (3,092 participants with diabetes; 23,494 controls) reported a prevalence of periodontal disease of 68% in participants with diabetes (combined types) and 36% in participants without diabetes. [13]

Diabetes is an important modifying factor of periodontitis and should be included in a clinical diagnosis of periodontitis as a descriptor. According to the American Academy of

Periodontology (AAP) classification of periodontal disease,[4] the level of glycemic control in diabetes influences the grading of periodontitis (i.e., a grade modifier). [14] [15]

Grade modifier [16]

Grade	HbA1c*
Grade A	No diabetes diagnosis
Grade B	HbA1c <7%
Grade C	HbA1c ≥7%
* Hemoglobin A1C [HbA1C], also called A1C, shows average blood glucose levels over the preceding 3 months.	

Research has shown periodontitis may be an early warning sign of diabetes and thus may serve as a valuable risk indicator for screening diabetes in oral healthcare. While effective diabetes management can lower susceptibility to periodontitis, evidence also suggests periodontal therapy can improve glycemic control. [5] [17]

Xerostomia[5]

Salivary gland dysfunction is a widely reported oral complication of diabetes, which can lead to decreased salivary flow and change in saliva composition. Dry mouth is one of the most common complaints in individuals with diabetes. The estimated prevalence of xerostomia ranges between 34% and 51%. Etiology is not known, but may be related to polyuria, autonomic neuropathies, microvascular changes, and alterations in the basement membranes of salivary glands. There is a significant relationship between the degree of xerostomia and glucose levels in saliva. Notably, the highest level of salivary dysfunction is observed with poor glycemic control. [4] [5]

It has been hypothesized that parotid innervation involvement related to diabetic neuropathy could be involved in the decrease of salivary flow, although studies present contradictory results. It is common to find asymptomatic parotid enlargement in individuals with diabetes, which has been interpreted as a compensatory mechanism for salivary hypofunction. [18]

Also, tricyclic antidepressants, frequently used to treat diabetic neuropathy, produce dry mouth. Other prescribed medications may cause xerostomia. For example, diabetes is frequently related to other pathological processes (e.g., hypertension) that require medications that may decrease salivary flow.[6] [18]

Xerostomia can produce serious negative effects on dietary intake, general and oral health, and quality of life. Effects of salivary hypofunction include:

- Susceptibility to dental caries, periodontal disease, and tooth loss
- Increase risk of oral infection, including candidiasis

[4] Refer to Episodes 49 and 50 for additional information of the AAP classification of periodontal disease.
[5] Refer to Episode 55 for additional information on xerostomia.
[6] Refer to Episode 62 for additional information on drug-induced xerostomia.

- Dry lips and mouth
- Dysgeusia (taste disturbances)
- Dysphagia (difficulty swallowing)
- Halitosis
- Mastication problems
- Chronic burning sensation
- Intolerance to spicy foods
- Difficulty wearing dentures (e.g., tolerance, retention, denture sores)
- Speech difficulty
- Sleep disruption
- Traumatic oral lesions [19] [20]

Xerostomia is managed by controlling blood glucose levels and utilizing common strategies to reduce dry mouth, such as:

- Drinking plenty water
- Sucking on ice chips
- Sugarless gum, mints, and lozenges (e.g., containing xylitol)
- OTC commercial saliva substitutes, moisturizers, and lubricants
- Use of self-adhering xylitol discs
- Limiting alcohol and caffeine intake
- Smoking cessation
- Using lip lubricants
- Drug substitutions if similar drugs are available with fewer xerostomic side effects
- Nighttime use of bedside humidifiers [21] [19] [20] [22] [23]

Dental caries[7]

Diabetes increases susceptibility to new and recurrent dental caries. Reduced cleansing and buffering capacity of saliva; increased glucose in saliva; and increased level of oral candidiasis, mutans streptococci, and lactobacilli may lead to an increase in the incidence of tooth decay. [4] [24] [25]

A systematic review and meta-analysis by Weijdijk et al. (2023) analyzed results from thirteen observational studies involving 21,220 participants using the decayed-missing-filled (DMF) index to compare dental caries in adults with and without diabetes. The analysis revealed a higher DMF index score in participants with diabetes, indicating a greater prevalence of dental caries in the diabetes population. [26]

[7] Refer to Episodes 86 and 87 for additional information on dental caries.

Periapical lesions

Chronic hyperglycemia may cause irreversible pulpitis[8] leading to pulp necrosis.[9] Diabetes is associated with higher prevalence of apical periodontitis;[10] greater size of periapical lesions; greater likelihood of asymptomatic periapical infections and delay of periapical repair; and higher rate of root canal therapy failure. [4] [27]

Some studies suggest chronic periapical disease may contribute to poor diabetes control. Research has shown root canal therapy improved apical periodontitis healing, glycemic control, and systemic inflammation in individuals with type 2 diabetes. [27] [28]

Diabetes may increase the risk of apical periodontitis after root canal therapy. A meta-analysis by Liu et al. (2023) assessed the risk of apical periodontitis in endodontically treated teeth in individuals with diabetes. A total of fifteen studies involving 1,087 participants with 2,226 teeth were included. The authors reported a statistically significant higher prevalence of apical periodontitis after root canal therapy at the tooth level, and a three times higher probability of developing apical periodontitis at the participant level. [29]

Tooth loss

Studies demonstrate diabetes is significantly associated with tooth loss. Major sources of tooth loss include periodontal disease and dental caries. Research indicates there is an increased risk of periodontal disease, and incidence and severity of dental caries in individuals with diabetes. A systematic review and meta-analysis by Ahmadinia et al. (2022) of 22 observational studies involving 677,532 participants found an association between type 2 diabetes and an increased risk for tooth loss by almost two-fold. [30]

A systematic review by Raju et al. (2021) examined the association between tooth loss and diabetes morbidity and mortality among adults aged ≥50 years. The review included thirteen observational studies. The study found significant associations of tooth loss with

[8] Irreversible pulpitis is a vital inflamed pulp incapable of healing warranting root canal therapy. Characteristics of symptomatic irreversible pulpitis include sharp pain upon thermal stimulus, lingering pain (often 30 seconds or longer after stimulus removal), spontaneous unprovoked pain, and referred pain. Sometimes the pain may be accentuated by postural changes (e.g., lying down, bending over). OTC analgesics are typically ineffective. Diagnosis may be difficult because the inflammation has not yet reached the periapical tissues, resulting in no pain or discomfort to percussion. In such cases, dental history and thermal testing are primary tools for assessing pulpal status. Asymptomatic irreversible pulpitis has no clinical symptoms and teeth usually respond normally to thermal testing. [50]

[9] Pulp necrosis is dental pulp death, necessitating root canal therapy. The pulp is nonresponsive to pulp testing and is asymptomatic. Pulp necrosis by itself does not cause apical periodontitis (pain to percussion or radiographic evidence of osseous breakdown) unless the canal is infected. Some teeth may be nonresponsive to pulp testing because of calcification, recent history of trauma, or the tooth is simply not responding. [50]

[10] Apical periodontitis is inflammation and destruction of the apical periodontium of pulpal origin. Symptomatic apical periodontitis produces clinical symptoms (e.g., pain upon biting and/or percussion or palpation). There may or may not be radiographic changes depending upon the stage of the disease (e.g., there may be a normal periodontal ligament width or there may be a periapical radiolucency). Severe pain to percussion and/or palpation usually indicates a degenerating pulp warranting root canal therapy. Asymptomatic apical periodontitis appears as an apical radiolucency without clinical symptoms (i.e., no pain on percussion or palpation). [50]

the prevalence and incidence of diabetes and adverse diabetes-related outcomes. Diabetes-related morbidities included greater prevalence of cardiovascular disease,[11] diabetic retinopathy, metabolic syndrome; poorer health-related quality of life; poorer survival with chronic kidney disease; and increased medical expenditure.

Increasing oral health and medical providers awareness of the role of tooth loss with poorer health outcomes is important. In addition, oral health providers should include diabetes screening[12] and self-care messaging in their client assessments and education, and medical providers should include oral health-related messaging during their client encounters. The authors concluded an interprofessional team-care approach that includes an oral health component could benefit the prevention and management of diabetes. [31]

Burning mouth

Burning sensation in the oral cavity is attributed to poor glycemic control, metabolic alterations in oral mucosa, microangiopathy, candida infection, and neuropathy. Symptoms may include burning or scalding feeling most commonly affecting the tongue, but also may affect the lips, gingiva, palate, throat, or entire mouth. These pain sensations have a considerable effect on physical and psychological functions, and are associated with sleep disturbance, anxiety, and depression. Neuropathy can affect the nerves of the taste buds producing an altered taste sensation. Many individuals with diabetes also experience numbness and tingling sensation of the tongue due to neuropathy. [4] [32] [33]

Delayed wound healing

Delayed healing of soft and hard tissues in individuals with diabetes is a well-known complication during oral surgeries. Factors associated with prolonged wound healing include delayed vascularization, diminished blood flow and hypoxia, weakened innate immunity, decreased growth factor production, and psychological stress. [4] [5]

Increased infections

Individuals with diabetes are more susceptible to fungal and bacterial infections, including more severe bacterial infections and their recurrence. This can be attributed to decreased salivary flow rate and the absence of its antimicrobial effects, impaired host defense mechanisms, and poor glycemic control. [4]

Xerostomia is a predisposing factor for oral candidiasis.[13] Salivary dysfunction can contribute to higher presence of fungi. Candida-related lesions include denture stomatitis, angular cheilitis, and median rhomboid glossitis. Candida infection is more prevalent in clients with diabetes who smoke, wear dentures, have poor glycemic control, and use steroids and broad-spectrum antibiotics. [4] [5]

[11] Refer to Episodes 37, 79, 80, and 81 for additional information on cardiovascular disease.
[12] Screening for diabetes includes a thorough medical history review and assessing for oral manifestations associated with diabetes, particularly periodontal disease.
[13] Refer to Episode 61 for additional information on oral candidiasis.

Taste dysfunction
Taste perception alterations, mainly hypogeusia (diminished sense of taste), have been reported in both type 1 and type 2 diabetes, in a significantly higher proportion than in individuals without diabetes. Taste dysfunction has been reported to occur more frequently in individuals with poorly controlled diabetes. Although the cause of taste perception alterations is currently unknown, many factors have been implicated, such as diabetic neuropathy and salivary hypofunction. Taste dysfunction can inhibit the ability to maintain a health diet, which can lead to poor glycemic control. [4] [18] [34]

Oral mucosa alterations
Several oral mucosa alterations (e.g., coated, fissured, and geographic tongue; recurrent aphthous stomatitis; lichen planus) have been associated with diabetes. Insufficient diabetes control, immunological alteration, microcirculatory changes with decline of blood supply, alteration in salivary flow and composition, and smoking have been implicated. [4]

Oral potentially malignant disorders (OPMDs)[14] are a significant group of mucosal disorders (e.g., lichen planus,[15] leukoplakia) that may precede oral squamous cell carcinoma diagnosis. A systematic review and meta-analysis by Ramos-Garcia et al. (2020) found individuals with diabetes had a significantly higher prevalence and risk of OPMDs as well as oral cancer[16] compared to the general population. In addition, individuals with oral cancer and diabetes had a higher mortality compared to those without diabetes with oral cancer. The study also showed a 2.5% prevalence of leukoplakia in individuals with diabetes, with a 4-fold higher risk of developing oral leukoplakia compared to the general population. [35]

Research has reported a 3% prevalence of oral lichen planus in individuals with diabetes, and a 2-fold increase of developing oral lichen planus compared to those without diabetes. Oral lichen planus also occurs more frequently with type 1 diabetes compared to type 2, possibly because they are both autoimmune diseases. [4] [18]

The reasons for increased oral cancer in individuals with diabetes are not well known, although clinical, biochemical, and molecular reasons have been proposed. Oral cancer and diabetes share several etiological risk factors, such as obesity, sedentary lifestyle, advanced age, and diet. Another possible link is related to hyperinsulinemia, due to insulin resistance, that leads to upregulation of some proproliferative and antiapoptotic[17] pathways. In addition, hyperglycemia generates oxidative stress with the release of reactive oxygen species (ROS) that could cause DNA damage. Hyperglycemia could also be accompanied by an increase in glucose consumption by tumour cells, which seems to increase cell proliferation. [18]

Increased cancer-related mortality may be due to:
- More aggressive cancer that develops in individuals with diabetes;

[14] Refer to Episode 76 for additional information on oral potentially malignant disorders**.**
[15] Refer to Episode 62 and 75 for additional information on lichen planus.
[16] Refer to Episodes 7, 9, 76, 77, and 78 for additional information on oral cancer.
[17] Antiapoptotic processes prevent apoptosis (programmed cell death to eliminate unwanted cells).

- General health deterioration because of diabetes complications (kidney disease, cardiovascular disease, etc.);
- Limitations for surgical treatment due to postoperative risks; and
- Higher postoperative mortality. [18]

Halitosis[18]
Approximately 25% of individuals with diabetes experience halitosis. The pathogenesis of this disorder may be related to:

- Xerostomia, which prevents adequate self-cleaning of the oral mucosa. Also, higher concentrations of methyl mercaptan and hydrogen sulfide have been reported in individuals with salivary secretion alterations.
- Frequent presence of dental caries, gingivitis, and periodontitis.
- Anaerobic bacteria, frequently isolated in oral infections of individuals with diabetes, produce volatile products that increase halitosis.
- Ketoacidosis associated with poorly controlled diabetes. [18]

Dental implants
Dental implant placement is generally a safe and reliable treatment in clients with properly controlled diabetes. Systematic reviews concluded implants in clients with diabetes have predictably high survival rates, provided good glycemic control and oral hygiene is maintained. However, systematic reviews have also advised clinicians to consider A1C values prior to implant placement and throughout the implant's lifespan, and to consider hyperglycemia as a major risk factor for peri-implant inflammation. In clients with poorly controlled diabetes, implant placement may have unpredictable prognosis, delayed osseointegration, and higher risk of failure. [7] [36] [37] [38] [39] [40]

Periodontal therapy
Glycemic control is a key factor in diabetes management and can be measured by A1C, which shows average blood glucose levels over the preceding three months. A1C can be reported as a percentage of total hemoglobin. Excellent glycemic control in an individual with diabetes is ~6.5%. [41]

A 2022 Cochrane review investigated the effects of periodontal treatment on glycemic control in individuals with diabetes and periodontitis. The review found moderate-certainty evidence that periodontal treatment using subgingival instrumentation improves glycemic control in individuals with both periodontitis and diabetes by a clinically significant amount when compared to no treatment or usual care.

The authors noted it is unnecessary to conduct further randomized controlled trials comparing periodontal treatment versus no treatment or usual care considering periodontitis treatment may improve glycemic control in individuals with diabetes and it is highly unlikely additional research will add new data to the evidence base. [41] [42]

Treating periodontal disease reduced the incidence of diabetes**,** and had a significant positive impact on healthcare costs. An analysis by Thakkar-Samtani et al. (2023) of

[18] Refer to Episode 67 for additional information on halitosis.

commercial insurance and Medicaid databases found a 12% and 14% decrease, respectively, in overall healthcare costs for individuals with diabetes who had received periodontal treatment, compared with individuals who did not receive treatment. The study also found periodontal treatment was significantly associated with reduced outpatient healthcare costs among individuals with commercial insurance or Medicaid. The authors concluded a healthy mouth can play a key role in diabetes management. Expanding Medicaid benefits to include comprehensive periodontal treatment has the potential to reduce healthcare costs for individuals with diabetes. [43]

Cognitive decline

A prospective analysis by Wu et al. (2023) showed diabetes and tooth loss together leads to an increased risk of cognitive decline. The research used 12 years' worth of data from the University of Michigan Health and Retirement Study to investigate the trajectory of cognitive decline among older adults with tooth loss (signifying poor oral health) and diabetes. The study included 9,948 older adults aged ≥65 years. The Health and Retirement Study included measures of memory and cognitive function, assessed every two years, along with questions about tooth loss, diabetes, and other health and demographic factors. In prospective analysis, the researchers were particularly interested in edentulous older adults.

The study found individuals who were edentulous and also had diabetes experienced the most significant and fastest cognitive decline compared with those who maintained their dentition and did not have diabetes. The results highlight the importance of access to oral healthcare for older adults, especially those with diabetes. [44]

Oral self-care[19]

A systematic scoping review by Lipman et al. (2023) found regular toothbrushing (at least twice-daily) was associated with better oral health outcomes and glycemic control in individuals with type 2 diabetes. Also, interventions to improve toothbrushing were associated with improvements in glycemic control and oral health, demonstrating coaching clients to improve oral self-care is more effective than simply educating them about toothbrushing. [45]

Tooth brushing frequency was also associated with risk of new-onset diabetes in a large retrospective study by Chang et al. (2020). In 188,013 participants followed for a median of 10 years, those who brushed three or more times daily were 8% less likely to develop diabetes compared with those who brushed less frequently. The presence of periodontal disease and number of missing teeth (≥15) were both linked to increased risk of developing diabetes by 9% and 21%, respectively. [46]

Luo et al. (2022) assessed the association between inflammation, oral health, and diabetes, as well as the mediating role of oral hygiene practice (measured by flossing). Data were from the 2009-2010 National Health and Nutrition Examination Survey (NHANES). The sample consisted of 2,191 participants ≥50 years. Poor oral health was clinically defined by periodontal disease and significant tooth loss (defined as lack of a

[19] Refer to Episode 89 for discussion on oral self-care.

functional dentition of <20 teeth lost). Diabetes was determined by glycemic levels. Serum CRP was also measured as a biomarker of acute and chronic inflammation.

The results showed having both significant tooth loss and diabetes; having significant tooth loss alone; and having diabetes alone were negatively associated with flossing, suggesting those with significant tooth loss or diabetes were less likely to floss frequently. Flossing was negatively related to elevated CRP, indicating frequent flossing was associated with lower risk of having elevated CRP.

The findings demonstrate flossing may mitigate inflammation, which may have important implications for diabetes management. Diabetes management is a complicated process and requires extensive self-care. However, most diabetes self-care focuses on physical exercise, diet, and medication adherence, whereas oral healthcare and good oral self-care practices have not been given adequate attention. The importance of regular oral healthcare and oral self-care needs to be emphasized to clients with diabetes.

The authors concluded significant tooth loss was associated with higher systemic inflammation. Flossing, an important oral self-care behaviour, may contribute to reducing this inflammation. The study findings highlight the importance of improving oral health and oral self-care practices to mitigate inflammation. [47]

Interprofessional collaboration

The 2023 consensus report of the Joint Workshop by the European Federation of Periodontology (EFP) and the European arm of the World Organization of Family Doctors (WONCA Europe) recommends close collaboration between family doctors and oral health professionals for effective prevention, early detection, and management of widespread noncommunicable diseases, including diabetes, cardiovascular diseases, respiratory diseases, and periodontitis.

The consensus report, authored by 18 global leading experts in periodontology and family medicine, updates and improves the scientific evidence supporting periodontitis is independently associated with diabetes, cardiovascular diseases, and respiratory diseases, (e.g., chronic obstructive pulmonary disease, sleep apnea, or COVID-19[20] complications).

Importantly, oral health clinicians can screen clients with periodontitis and identify those with diabetes or prediabetes who have not been previously diagnosed. Closer collaboration between oral health professionals and family doctors is important in the early detection and management of noncommunicable diseases, such as diabetes, and in promoting healthy lifestyles. [11]

Take home messages

- Diabetes is a common condition oral health professionals will frequently encounter.

[20] Refer to Episode 59 for discussion on the relationship between COVID-19 and diabetes.

- It is important to be familiar with the links between oral health and diabetes to assist in educating clients about the relationship and coaching them towards better oral health and self-care.
- Screening for diabetes in oral healthcare is important since early identification and referral of individuals at high risk for diabetes or with undiagnosed diabetes will help prevent or delay progression from prediabetes to overt diabetes and to reduce the incidence of chronic oral and systemic complications.
- Periodontal diseases are a common complication of diabetes. Oral health professionals must remain vigilant treating these conditions in clients with diabetes to help maintain and improve glycemic control.
- Collaboration between oral health and medical professionals is vital to address oral health needs of clients with diabetes to improve their overall health and well-being.

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Brushing, Flossing, Rinsing, ODHA Factsheet
https://odha.on.ca/wp-content/uploads/2016/08/Brushing-Flossing.14.1-copyright.pdf

Dry Mouth, ODHA Factsheet
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Additional Resources

CDHO Factsheet: Diabetes Mellitus, May 3, 2023
https://cdho.org/factsheets/diabetes-mellitus/

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https://cdho.org/advisories/diabetes-type-1-2-or-gestational/

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