

DRY MOUTH: A CLINICAL PROBLEM FOR CHILDREN AND YOUNG ADULTS

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Introduction

The subjective sensation of dry mouth, xerostomia, is a well recognized problem in adults, however relatively little attention has been paid to this issue in children. Because infants drool and young children always seem to have an excess of watery saliva, there is an unfounded belief in the dental profession that children cannot or do not suffer from salivary hypofunction, i.e. xerostomia or dry mouth. Regrettably, this is not so. Many children with special needs or complicating medical factors can suffer significant impairment of salivary function (Table 1).

A normal child will show a stimulated salivary flow rate of greater than 1.0 mL/min, somewhat higher than the value for an adult (0.7 mL/min)³⁹. Dry mouth occurs when the resting salivary flow rate is less than the rate of fluid loss from the mouth - either by evaporation or by absorption of water through the oral mucosa. By definition, evaporation can only occur during mouth-breathing, and it has been estimated that it could reach a maximum rate of 0.21 mL/min, although normally, even in a mouthbreathing patient, it would be much less.⁴⁰ Saliva in the residual volume is present as a thin film, which varies considerably in thickness with site, being thinnest on the hard palate. Symptoms of oral dryness may be due to localized areas of mucosal dryness, notably in the palate. Unstimulated salivary flow rates >0.1-0.3 mL/min may be necessary for this condition to be avoided.

Prompted by the sensation of mucosal dryness, individuals seek fluids to drink. It is interesting that two important determinants of mouth wetting are temperature and acidity. Cold or acidic beverages are more likely to be regarded as "thirst-quenching".⁴¹ Because beverages can differ in their satiating ability, there is a risk that the frequent use of cold acidic drinks (such as cordials and softdrinks) in children conditions them to seek these in later life, in the same way that frequent exposure to sugar can establish a pattern for the later years. A particular concern is that children may be able to readily access caffeine containing beverages such as cola drinks, which have an addictive component (the caffeine) leading to a pattern where the drivers of caffeine, sugar, cold and acid all operate together, albeit subconsciously, to affect behaviour. As the mouth becomes drier, gustatory sensitivity declines,⁴² and higher concentrations are needed to sustain the

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Table 1.
Potential contributing factors to salivary hypofunction in children

Negative fluid balance from

- insufficient water intake
- intake of caffeine (e.g. black cola drinks)
- Type I or Type II diabetes mellitus^{4,8,24,28}
- haemodialysis for renal disease¹³
- eating disorders¹⁰

Medication effects

- decongestants
- caffeine in asthma medications
- amphetamines for attention deficit hyperactivity disorder¹⁶
- anti-anxiety medicines for obsessive compulsive disorder²⁰
- antihistamines for allergic rhinitis
- chemotherapy for childhood cancers^{12,21,22}

Salivary gland injury

- Paediatric HIV infection⁹
- Graft-versus-host disease in bone marrow transplant recipients^{7,12,14,25}
- Early onset Sjogren's syndrome and autoimmune disorders^{6,17,19,23}
- Radiotherapy for solid tumours or leukaemias¹⁴

Uncommon causes

- Salivary gland agenesis (lack of gland formation)^{1,5,11,15}
- Salivary gland duct malformations²⁷
- Ectodermal dysplasia (hypodontia with syndromal associations)^{2,3}
- Oligodontia (with syndromal associations)³

same level of stimulation. This can drive high levels of intake of such beverages. The dental consequences of high cola drink intakes in children are catastrophic in terms of dental caries and dental erosion.

As has been well documented in adults,⁴³ depressed resting flow and pH at rest is associated with lower plaque pH, increased numbers of lactobacilli and *Candida* species, and greater caries risk.^{44,45} The factors which contribute to salivary dysfunction in children are, in broad terms, no different from those in adults. In short, any factor that reduces body fluids, affects the gland's parasympathetic innervation, or directly

damages the glands, will reduce salivary output. This will have consequences for caries activity, and will also increase the risk of tooth loss via dental erosion.³³

Thus, the most at-risk children for salivary hypofunction are those with medical conditions affecting salivation either directly or indirectly, those using medications which have xerostomic effects, and those whose pattern of school and extra-curricular activities places them at risk of negative fluid balance. Normal salivation, by buffering and clearing acids, contributing to pellicle formation, and providing the ions needed for remineralization of demineralized enamel, protects the teeth from both the bacterial-derived organic acids that cause caries, and the extrinsic and intrinsic acids that initiate dental erosion.⁵

The initial presentation of the child with salivary hypofunction may be triggered by symptoms of oral dryness or impaired oral function, the development of oral mucosal pathology such as oral thrush, or pain from carious teeth. In children with severe and long standing oral dryness, recurring infections of the salivary glands themselves (e.g. by Staphylococci) and of the oral mucosa (e.g. herpes labialis and tonsillitis) have been reported.³⁴ Patients who complain of oral dryness typically have additional symptoms of oral dysfunction indicative of a reduced resting flow rate,⁴⁶ and thus the assessment of the patient in the first instance must be thorough or this information will be overlooked. Labial lesions of decalcification on maxillary incisor teeth are a classic sign in young patients with salivary dysfunction, and the location of these is explained by the nature of plaque accumulation cervically and the low pH, slow moving nature of the salivary film at this particular location within the oral cavity (Figures 1-4). Once stimulated saliva samples have been collected to assess flow rate, pH and buffer capacity, the sample can also be tested for the presence of *Streptococcus mutans* bacteria using chairside immunoassays (Fig. 5).

Diagnostic approach

Approaching the subject mainly by taking a symptomatic approach, which relates to the presenting complaint or oral dryness, is a useful first step when salivary dysfunction is noted in a child.⁴⁴ Chairside salivary diagnostic tests (Figs. 5 and 6) and careful assessment of lifestyle factors should be undertaken, and the results from these used to assess the need for referral to specialists in oral medicine, paediatric dentistry, or special needs dentistry, as appropriate. These individuals will work towards firming the diagnosis and designing a home care plan to achieve stability.

Reaching a firm diagnosis of the underlying causes of salivary gland hypofunction may not be straightforward. Acquisition of samples of saliva for complex biologic, microbiological,

immunologic and or chemical analyses is difficult in infants and young children due to lack of cooperation and motor skills necessary for expectorating adequately.⁴⁸ Use of absorbent tips has proven useful for collecting defined volumes of saliva at rest, and this technique has been used successfully in infants only days old.⁴⁹

In the very young, complex imaging using ionizing radiation is neither safe nor practicable, and ultrasound provides a safe alternative approach. In older children, a range of imaging modalities can be used, including plain radiography, sialography, computed tomography (CT), magnetic resonance imaging (MRI), and radionuclide imaging (scintigraphy). In the latter, a radioactive (gamma emitting) label, generally technetium (Tc 99m) pertechnetate, is injected into the patient and its uptake across various tissues of the body measured in a gamma camera. The label binds to the Na-K-Cl membrane transport system of the acinar cells of the salivary glands.

Contributing factors to salivary hypofunction

1. Excessive fluid loss

This can occur from multiple lifestyle factors (such as exertional sporting activities), or from persisting GIT fluid loss, for example from diarrhea in children with Crohn's disease and food intolerances, or in children with eating disorders, such as anorexia nervosa with restricted oral intakes or binge/purge disorders. Such eating disorders can occur in both males and females, before the age of 10 years. In patients with eating disorders, xerostomia is a common finding, and the salivary deficit greatly compromises the potential for repair after the erosive challenges.⁴⁹

Mouthbreathing is a potential factor which could contribute to oral dryness, however in studies which have compared microbiological and salivary factors in treated and untreated children with mouthbreathing syndrome, no significant differences have been found in caries risk between these groups, although the level of IgG antibodies to *S. mutans* was higher in the treated group.⁵⁰ Similar studies which have compared adolescents aged 10-19 years who were mouth-breathers or nose-breathers failed to find differences in flow rates or buffering capacities of resting and stimulated saliva.⁵¹ Overall, there is little evidence to suggest that mouthbreathing is a risk factor for dental caries in children. Nevertheless, some patients who mouthbreathe may report that their mouth is dry. As already noted, this does not mean they have a complete lack of fluid in the mouth; rather, they may have localized areas of dryness on the hard palate, where the salivary film has become thin from evaporation because of mouth breathing.⁵²

2. Medications

Medications used for a number of childhood diseases and

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Figure 1: The development of mature aciduric biofilms occurs rapidly on maxillary incisor teeth in children with low resting salivary flow rate and pH. In this example, the plaque has been stained using a 2-tone dye (GC Corporation) which shows the mature biofilms (purple) cervically, while thin, aerobic plaque (pink) extends up the labial surface.



Figure 2: In this patient extensive white spots have developed on the maxillary incisor teeth. The mandibular incisors gain the most protection from saliva and are the last teeth affected by caries in both adults and children, even when the assault is intense and prolonged.



Figure 3: The decalcified surface has now cavitated, while the lower incisors have white spot lesions.

conditions can adversely affect salivary output. The clinician must be alert to the fact that medications used to manage serious medical disorders, such as attention-deficit/hyperactivity disorder (ADHD) or obsessive-compulsive disorder (OCD), can cause profound xerostomia. If appropriate prevention is not in place to combat this greater challenge, the resulting dental caries will compound the management of the child.

ADHD is the most common neurobehavioral disorder affecting school-age children. In many cases, symptoms persist into adolescence and adulthood, causing significant lifelong impairments in academic, career, and social functioning.⁵³ Children with ADHD have significantly more caries in the primary and permanent dentitions when compared to controls.⁵⁴ One reason for this could be a reduction in resting



Figure 4: In this patient in the late teenage years, pharmacological desalivation by illicit drugs (amphetamines) has resulted in catastrophic destruction of the dentition, within two years after the completion of orthodontic treatment. Note that in this case the presence of cavitations in the lower incisor teeth signals the extreme caries activity.

salivary pH, since to control severe hyperactivity and impulsivity, stimulants such as methylphenidate and amphetamines have been used for many years. More recently, non-stimulant therapies have been explored including atomoxetine, alpha-adrenergic agents, antidepressants, guanfacine and modafinil.⁵³ Impaired salivary production at rest is a side effect of almost all drugs used in the management and treatment of ADHD.

Similar comments apply to OCD, where supportive medications used such as selective serotonin reuptake inhibitors (SSRIs) (paroxetine, fluoxetine, fluvoxamine, and sertraline) and clomipramine have the potential to impair

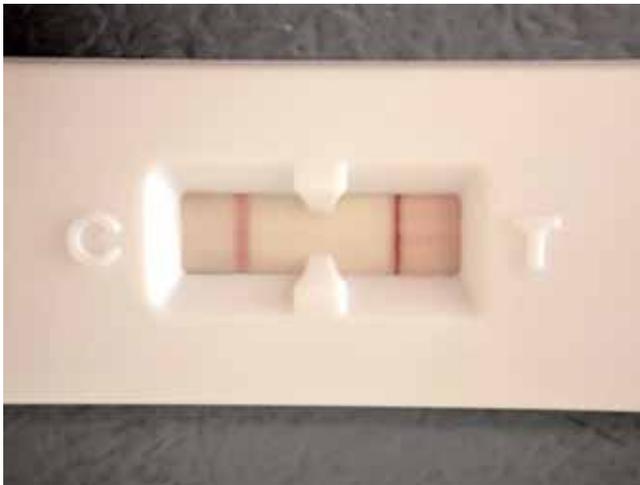


Figure 5: Sample of stimulated saliva from a child tested for the presence of *Streptococcus mutans* bacteria using the Saliva Check SM test kit (GC Corporation). The positive result is indicated by the line on the test (T) well, signifying 500,000 bacteria per mL. The control result (C) indicates correct function of the direct immunoassay.

resting salivary flow and pH.^{55,56} The suppressive effects of SSRI and tricyclic antidepressants are profound, and extend beyond suppressing resting parameters to reducing stimulated salivary flow.⁵⁷ Rampant caries has been linked causally with tricyclic antidepressants and other anticholinergic psychoactive drugs, yet mental health professionals may not be fully cognisant of the dental health risks of long term use of such medications.⁵⁸

Antihistamines are commonly used in children, and their effects on salivary flow is deserving of further comment. Terfenadine is an antihistamine formerly used for the treatment of allergic conditions. It was marketed under the brand name Teldane in Australia. Resting saliva flow has been shown to be unchanged by terfenadine despite the fact that it induces mild drowsiness in nearly one third of patients.⁵⁹

Careful studies of children with asthma have documented that they have suppressed salivary flow rate and pH compared with healthy controls, together with, not surprisingly, a higher caries prevalence compared with healthy controls at the same age. Longer use of anti-asthma medications has been linked with greater reductions in salivary pH, and higher salivary levels of *S. mutans* in asthmatics.¹² These indicate that asthma pharmacotherapy adversely affects risk factors for dental caries, and may directly contribute to salivary dysfunction in children.

3. Diabetes mellitus

Both insulin-dependant and non-insulin-dependant forms of diabetes can occur in children, with documented reports for children from the ages of 5 years onward.⁹ Xerostomia is a common occurrence in such patients because of polyuria and its associated fluid loss, as an attempt to reduce blood glucose levels. Diabetic children have higher DMFT rates, with mandibular first molar teeth being particularly affected by

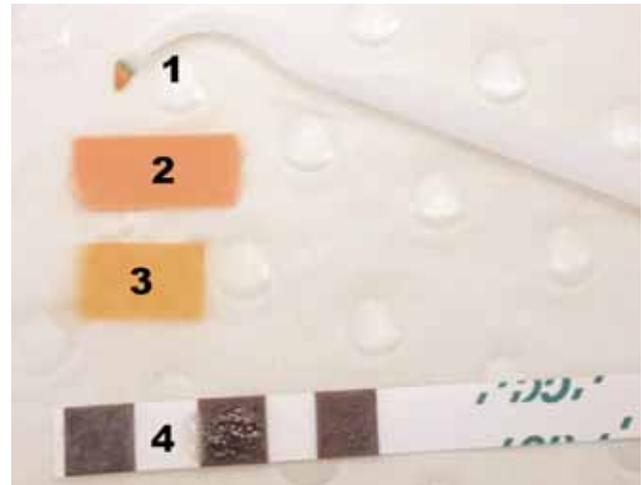


Figure 6: Plaque and saliva test results obtained using the GC Plaque Check-pH and Saliva Check Buffer test kits, in a 10 year old child which should raise the alarm. The plaque sample taken from the cervical aspect of the maxillary central incisor has a high level acid production when challenged with sucrose, giving a red colour for final pH (less than 5.5) (1). The resting saliva pH is low (2) and the stimulated pH is only slightly higher, suggesting a structural cause of the hypofunction rather than lifestyle factors. This is confirmed by the low buffering capacity (4). The child suffered from graft-versus-host disease following an allogeneic bone marrow transplant, with immunologically mediated salivary gland injury despite immune suppressive medications.

caries in the deciduous and permanent dentitions. Screening for diabetes mellitus should be considered for all patients exhibiting asymptomatic parotid enlargement, regardless of their age.⁶

4. Chemotherapy and radiotherapy

Cytotoxic chemotherapy is used to treat a range of solid tumours and haematological malignancies in children. This directly damages salivary gland acinar cells, thereby reducing salivary outputs at rest and when stimulated. Local field or total body irradiation impairs salivary outputs, although the effects of the latter are less severe and recovery can be expected over several months.²¹

5. Graft-versus-host disease

With the increasing number of children receiving bone marrow transplants, it is likely that these patients may appear for care in a general dental practice setting. Despite the use of immune suppressants such as cyclosporin and tacrolimus, patients who receive marrow, cord blood or stem cells from a non-genetically identical donor develop graft-versus-host disease (GVHD), an inflammatory condition which damages the skin, gastrointestinal tract, liver, oral mucosa and salivary glands in particular, and other body sites to a lesser extent. Patients with moderate to severe GVHD suffer profound xerostomia, while in mild GVHD symptoms of oral dryness may be less apparent, even though salivary parameters are below the normal range.^{24,26} Rampant caries is a major risk in the post-transplant years.

6. HIV infection

Salivary gland disease is a very common manifestation of HIV infection in children, with the parotid glands being the most frequently affected of the major glands. These glands may be visibly enlarged. Salivary gland involvement in HIV disease leads to dramatic reductions in saliva parameters, the effects of which account for significant morbidity during the progression of HIV disease.²²

7. Sjogren's syndrome

While the typical presentation of Sjogren's syndrome is in a female in the 5th decade of life, there are reports of children with multi-focal autoimmune disease which has manifested in the first year of life, going on to develop glandular and extraglandular manifestations, including arthralgia and arthritis. Such patients experience severe caries which affects all teeth as soon as they erupt into the oral cavity.³⁰ The diagnosis should be considered, however, in children with a gritty sensation in the eyes, long standing dryness of the eyes or mouth, or recurrent salivary gland enlargement.²⁸

8. Ectodermal dysplasia

This inherited condition is manifested as malformations of all tissues originating from the ectoderm. Impaired function of the

sweat glands, hair, or nails is common in this condition. From the dental perspective, this means severe hypodontia, dental malformations, hypoplasia of the alveolar process, and xerostomia. In such patients, almost invariably, all third molar teeth are missing, however ignoring their contribution, common missing teeth are maxillary lateral incisors, mandibular central incisors, and mandibular second premolars.^{37,38} While maxillary central incisors are unlikely to be missing, these teeth are often affected by severe malformations. The need for many of these patients to wear removable partial dentures and undergo orthodontics makes it essential that their salivary risk factors are addressed comprehensively. Often one third of patients with ectodermal dysplasia have severe xerostomia (unstimulated salivary flow rate of <0.1 mL/min and/or stimulated salivary flow rate of <0.7 mL/min).³⁸

9. Oligodontia

Oligodontia, which is defined as the congenital absence of six or more permanent teeth, can be divided into two broad groups: isolated oligodontia, and oligodontia that is part of a syndrome. A recent study identified that more than 140 syndromes have been described where a component was oligodontia. Testing of salivary flow parameters is strongly recommended in individuals with oligodontia as most children

with depressed salivary flow rates will not subjectively perceive dryness of the mouth. ³⁸

10. Salivary gland agenesis (lack of gland formation)

Partial or total agenesis of salivary glands can occur, and the classical presentation of this is the 'non-drooling infant'. Salivary gland agenesis is, fortunately, a rare disorder, and it can appear singly (e.g. from a spontaneous mutation), or in combination with other genetic disorders. ³⁴ As well as causing profound xerostomia, and being linked causally with aggressive caries, recurring candidal infections, and ascending sialadenitis, salivary gland agenesis has also been linked with tonsillitis, laryngitis and pharyngitis, as well as with abnormalities of the tear-producing lacrimal glands. ^{32,35}

A key management point with children where salivary gland agenesis is suspected is that symptoms may not be reported. In a series of six cases, where the children had been referred for treatment of rampant dental caries, none complained of excessive thirst or difficulty with mastication or swallowing. The presence of carious lesions in the lowest risk site, i.e. lingual surfaces of mandibular incisors, should alert the clinician to the possibility that salivary glands may be absent. ³¹

In addition to complete or partial agenesis of major salivary glands, congenital malformation of portions of the salivary ducts may occur, resulting in recurring infections (ascending parotitis). This can manifest from as early as 3 months of age. As in Sjogren's syndrome, dehydration of the oral cavity and loss of salivary antibacterial defenses appear to be major contributing factors. ³⁶

Home care programs

This should be based on a "common risk factor" approach, addressing dietary factors, lifestyle choices, salivary factors, and plaque factors. ⁶⁰

In the child with ongoing salivary dysfunction, lifelong therapy utilizing salivary substitutes, CPP-ACP, fluoride varnish applications, intermittent chlorhexidine therapy, strict adherence to diet, and regular dental reviews are essential to prevent the early loss of both deciduous and permanent teeth and potential difficulties downstream in coping with dentures.

For children who are old enough to expectorate properly, the use of products in gel or mouthrinse forms is appealing, for example GC Tooth Mousse, chlorhexidine gels, and toothpastes. In high risk patients above age 7, daily mouthrinses using 0.05% NaF could be used, or the fluoride delivered using a fluoride dentifrice in combination with GC Tooth Mousse Plus, which contains 900 ppm fluoride. In older children and young adults, high fluoride toothpastes are effective, and compliance is generally excellent since these can substitute for conventional dentifrices. ⁶¹

If mouthrinsing solutions are recommended, care must be taken that in patients of any age with dry mouth, compliance problems will surface if the rinse has irritant or desiccant

properties in terms of the oral mucosa. Ethanol containing products must not be recommended to children for long-term use, and all products containing high concentration of detergent components should be avoided as these may reduce the substantivity of some therapeutic agents and will worsen the symptoms of oral dryness.⁶²

Early detection of salivary gland hypofunction in children is important for preventing the deleterious oral affects which follow the absence of salivary protection in the oral cavity.³⁴ It is critical that any materials used to augment or replace saliva have a neutral pH, so that acidic conditions are not sustained in the oral cavity for any length of time. Somewhat surprisingly, most saliva substitutes have not been designed with this parameter in mind. In healthy patients, the mean pH of all sites in the mouth at rest is 6.78, with typical values being 7.34 for the palate, 6.5 for the floor of the mouth, 6.28 for the buccal mucosa, and 6.8 for the tongue.⁶³ With a neutral pH, contemporary products such as GC Dry Mouth gel provide effective symptomatic relief, whilst preserving oral pH.

Where functional salivary gland tissues remain, stimulation of these using a sugar-free gum is an essential oral health measure. Gums which contain both CPP-ACP and xylitol would be preferred, because of the remineralizing capabilities of the CPP-ACP and the simplicity of this mode of delivery. Xylitol, which is a naturally occurring sweetener, cannot be fermented by cariogenic bacteria, and its incorporation into gums leads to impressive reductions in caries incidence in children, when these are used on a regular basis. Advantageously, xylitol is compatible with and complementary to other home care products and strategies.⁶⁴ Prolonged use of xylitol or xylitol containing chewing gum reduces *Streptococcus mutans* counts in plaque and saliva, the acidogenic potential of the plaque, and the adhesiveness of plaque, whilst increasing its mineral content. No adaptive changes in plaque metabolism occur, even after long term, regular use.⁶⁵

Patients must be carefully instructed not to suck citrus-flavoured sweets to stimulate saliva flow. If they wish to use a product, sweets based on xylitol or isomalt should be sought, which are non-cariogenic and have a low glycaemic index. Another alternative are lozenges which include CPP-ACP and other preventive materials. By carefully selecting appropriate products, both dental health and nutritional aspects can be optimized.

Disclosure

The author contributed to the development of the chairside diagnostic kits for saliva and dental plaque produced by GC

Corporation, and has a commercial interest in the latter.

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