



Farima Mehrabi

Dáire Shanahan and Gemma Davis

# Xerostomia: Part 2. Investigations and Management

**Abstract:** Xerostomia is the subjective sensation of a dry mouth. It can negatively impact oral health and quality of life. This article reviews the investigations and management of xerostomia. Early recognition and management of xerostomia is important to limit the adverse effects that can be caused by this condition.

**CPD/Clinical Relevance:** Awareness of the possible aetiologies and oral manifestations of xerostomia are important for the general dental practitioner.

**Dent Update 2022; 49: 873–878**

In the first part of this two-part series on xerostomia, or dry mouth, the aetiology and oral manifestations were explored, with particular attention being paid to the impact dry mouth can have on both a patient's oral health and their oral health-related quality of life. In Part 2, its diagnosis and symptom management are discussed.

## History

When diagnosing xerostomia a thorough history should be obtained from the patient in order to establish the duration and severity of their symptoms, as well as the impact on the patient's quality of life. The history should then be focused to try and identify any potential underlying causes, such as associated systemic diseases including diabetes mellitus and rheumatological conditions that may

raise the suspicion of Sjögren's syndrome. A comprehensive drug history should then follow to identify whether the patient is taking any medications that are implicated in inducing xerostomia. A social history including smoking status, alcohol consumption and illicit drug use should also be taken.

## Examination

Examination should begin extra-orally, paying particular attention to the presence of any salivary gland swelling and signs of dry eye, including eye redness and blurred vision. Intra-oral examination should include a thorough soft tissue examination looking for clinical features of xerostomia, including a dry lobulated tongue dorsum, lack of saliva pooling in the floor of mouth and oral candidiasis. Massage of the

major salivary glands and ducts can be performed to assess for the presence of any blockages.

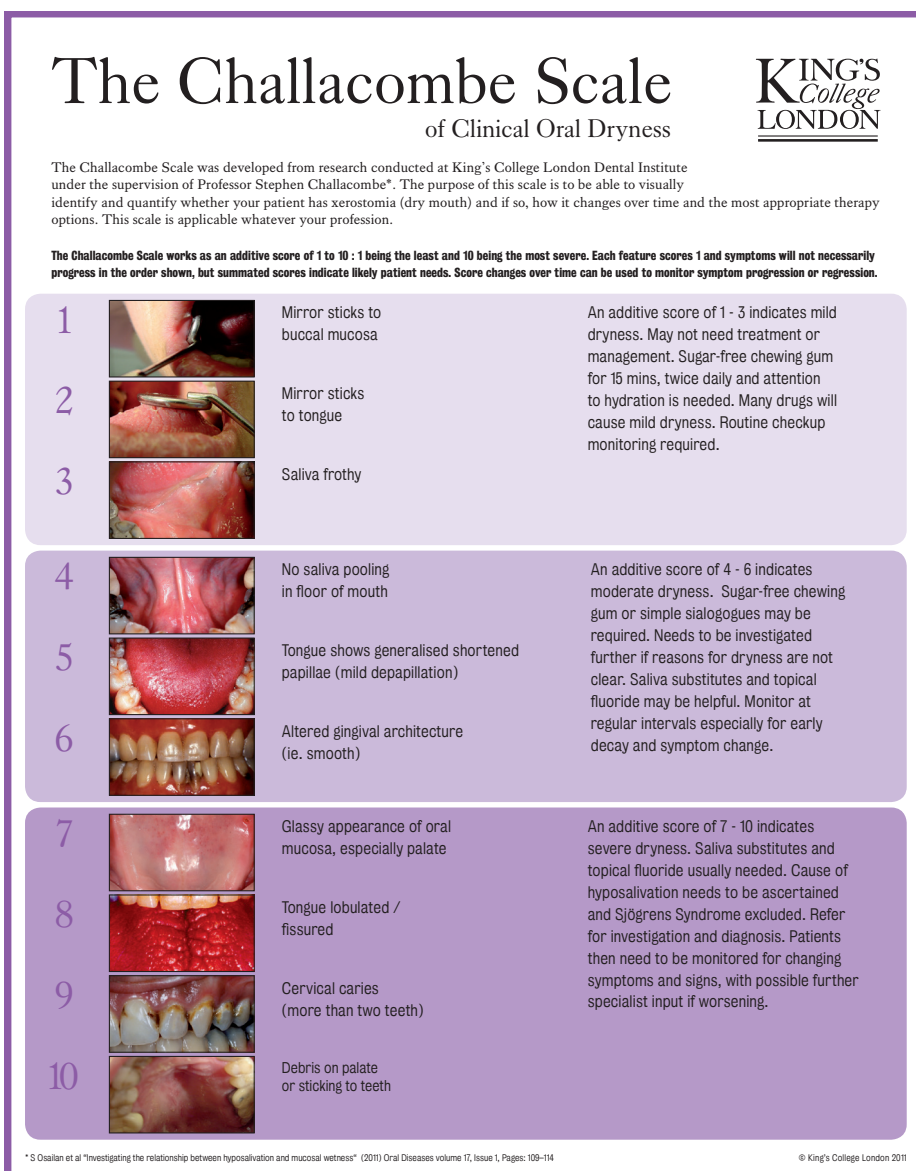
As an adjunct to a thorough history and examination, there are several subjective and objective forms of measurement that can assist with diagnosis and ascertaining the severity of xerostomia. These tools can help to determine whether further investigation and/or referral to a specialist is required.

## Investigations

### Subjective methods of measurement: assessment scales

The Challacombe scale of clinical oral dryness (Figure 1) is used to visually identify and quantify xerostomia, and may be used to assess for change over time. Each feature on the scale scores one point and the total is collated. A low score of between 1 and 3 indicates mild dryness that can be managed in practice. A high score of 7–10 indicates a need for referral and further investigation.<sup>1</sup> Based on the patient's clinical oral dryness score, the scale provides guidance on appropriate management, including when to prescribe saliva substitutes

**Farima Mehrabi**, BDS, MFDS, RCSEd, PgCertMedEd, FHEA, Specialty Registrar, Birmingham Dental Hospital. **Dáire Shanahan**, BA BDentSc, MBBCh, MFDRCSI, Specialist Trainee in Oral Medicine, University of Bristol Dental Hospital. **Gemma Davis**, BDS, MFDSRCS (Eng), PgCertTLHP, Specialist Trainee in Oral Medicine, University of Bristol Dental Hospital.  
email: f.mehrabi@nhs.net



**Figure 1.** The Challacombe Scale of Clinical Oral Dryness.<sup>3</sup>

and apply topical fluoride. These scores should be monitored over time and evaluated against symptom progression or regression.

The Xerostomia Inventory is a validated 11-item questionnaire. The responses to which are combined into a single continuous scale score, which in turn represents the severity of the xerostomia. The higher the score achieved, the more severe the symptoms.<sup>2</sup>

### **Salivometry, serology, clinical imaging and biopsy**

Salivometry, or the measurement of salivary output, can be undertaken in various ways (Table 1). Table 2 outlines the different methods for salivary imaging.

### **Salivary gland biopsy**

Labial gland biopsy is one of the key investigative modalities used for the diagnosis of Sjögren's syndrome (SS). The procedure is carried out under local anaesthesia, and the lower lip is in the anatomical position of choice. A superficial incision is made lateral to the midline, around 1–1.5 cm in size. A sample of 6–8 glands is then sent for histopathological analysis.<sup>5</sup> The most characteristic histopathological feature seen in SS is focal lymphocytic sialadenitis, which is defined as the presence of tight aggregates of 50 or more lymphocytes usually found adjacent to normal glandular tissue in periductal or perivascular locations.<sup>6</sup> The number of

these aggregates seen in a 4-mm<sup>2</sup> area is known as the focus score. Other non-specific features such as gland fibrosis and duct dilation may also be seen.

Post-operative complications include bruising, bleeding, pain and swelling, with or without transient (12%) or permanent (6%) paraesthesia of the mental nerve persisting beyond 6 months and/or damage to adjacent minor salivary glands.<sup>5</sup>

A thorough decision-making process should be undertaken by the clinician to consider the potential benefits and risks to the patient from this procedure, with the patient's views being heavily weighted.

### **Blood tests**

A number of blood tests can be carried out in the investigation of dry mouth, mainly to exclude diabetes, SS, sarcoidosis and viral infections. The tests performed are based on the history and clinical examination findings. Examples of commonly used tests include:

- Full blood count: may see anaemia, leukopenia, and thrombocytopenia in SS;
- HbA1c: may reveal undiagnosed, poorly controlled diabetes;
- Immunological tests: autoantibodies (rheumatoid factor, antinuclear antibody, and SS-A/Ro and SS-B/La) are typically seen in SS;
- Erythrocyte sedimentation rate (ESR): typically raised in SS;
- Infection screen: to exclude HIV and hepatitis C.

## **Clinical management**

### **Prevention: diet and habit modifications**

Patients presenting with xerostomia can be advised on a number of diet and habit modifications to prevent the worsening of symptoms and potential side effects. Patients can be encouraged to take frequent and regular sips of water throughout the day, and to avoid excess intake of caffeine and alcohol, which may exacerbate the sensation of dry mouth.<sup>7</sup> Dry, hard, sticky or acidic foods should not be recommended and patients should be instructed to reduce their sugar intake to circumvent the probability of dental caries in an already high-risk oral environment.<sup>7</sup>

The National Institute of Clinical Excellence (NICE) recommends a

Unstimulated whole salivary flow	<1.5 ml in 15 minutes is decreased (<0.1 ml/min)
	Patient to periodically expectorate saliva or to let it passively drain from mouth into a pre-weighted measuring container over 15 minutes To be carried out first thing in the morning prior to brushing teeth, eating food or social habits such as smoking
Stimulated whole saliva flow Gustatory stimulation using 1–2% citric acid applied to the lateral borders of the tongue at 30-second intervals Masticatory stimulation by chewing on unflavoured paraffin wax or sugar-free gum	<0.5 ml per gland in 5 minutes is decreased
	Patient to periodically expectorate saliva into a pre-weighted measuring container over 5 minutes
Ductal flow of major salivary glands	Parotid: A collection cup (Lashley or Carlson-Crittenden cup) placed over Stenson's duct
	Submandibular and sublingual: aspiration of saliva that pools in the floor of mouth using syringe

**Table 1.** The different methods for measuring salivary output.

Sialography (conventional/fluoroscopic, CT or MR)	Most commonly images the parotid gland Used as a diagnostic instrument for Sjögren's syndrome, when sialolithiasis or salivary duct obstruction is suspected. When sialadenitis is suspected to identify possible ductal strictures or when sialectasis is suspected in inflammatory disorders
Magnetic resonance imaging	Used in the detection of tumours
Plain film	Used for identifying salivary calculi
Computed tomography	Used in the detection of tumours
Ultrasonography*	Detects salivary gland structural changes In the early stages of Sjögren's syndrome, the major salivary glands may appear normal or generally less well defined. In later stages, punctate hypo-echoic (darker) lesions can be seen along with destructive changes resulting in a characteristic multicystic pattern <sup>4</sup>
Chest radiograph	If Sarcoidosis is suspected

**Table 2.** The different methods for undertaking salivary imaging. \*Ultrasonography is a non-invasive and simple method of identifying changes in the salivary gland in patients presenting with symptoms of Sjögren's syndrome. At present there is no validated scoring system; however, evidence to support its use in Sjögren's syndrome is compelling.

3-month recall for patients who are considered to be at a high risk of oral diseases, such as those with significant hyposalivation.<sup>8</sup> This category of patients should also be provided with increased fluoride use, this includes:<sup>9</sup>

- Fluoride varnish (2.2% NaF) to be applied to teeth twice yearly;
- Fluoride toothpaste (5000ppm);
- Fluoride mouthwash daily (0.05% NaF) to be used at a different time to brushing.

#### Symptom management with salivary substitutes

Artificial salivary substitutes have been shown to provide symptomatic relief in patients presenting with xerostomia through the moistening of the oral mucosa (Table 3).<sup>10</sup> They are typically effective for no more than a few hours, and are more commonly used to aid with talking or when patients wake during the night. In order for them to be effective, they need to be used frequently over a long period of time. Salivary substitutes come in a number of forms and

are available on the market as rinses, sprays, gels, lozenges, toothpastes and reservoirs in dentures. They can be categorized by their contents, namely containing either: glycerin and lemon, or carboxymethylcellulose and mucin.<sup>10</sup> Patients should be made aware of the ingredients because mucin is a porcine derivative and therefore is not suitable for patients in certain religious groups (eg Islam, Judaism) as well as vegetarians or vegans.

Salivary substitutes not only provide lubrication for the oral mucosa, but they also can aid in preventing bacteria and

Product name	What form it comes in	Buy from the pharmacy?	pH	Contains fluoride?	Animal ingredients?
AS Saliva Orthana	Oral spray (50 ml)	Yes	Neutral	Yes	No – vegan friendly
	Lozenges (30s)	Yes	Neutral	No	
Biotene Oralbalance	Saliva replacement gel 50 g	Yes	Neutral	No	Yes (animal unknown)
BioXtra	Moisturizing gel 40 ml	Yes		No	Cows' milk
	Gel mouth spray 50 ml	Yes		Yes	
	Toothpaste 50 ml	Yes		Yes	
	Mouthrinse 250 ml	Yes		Yes	
Glandosane	Aerosol spray 50ml (lemon, neutral, peppermint)	Yes	Acidic – may cause damage to natural teeth	No	No
Saliveze	Oral spray 50 ml	Yes	Neutral	No	No
SST Saliva Stimulation Tablets	Tablets (100)	Yes	Acidic – may cause damage to natural teeth	No	No
Xerotin	Oral spray 100 ml	Yes	Neutral	No	No
Oralieve	Moisturizing gel 50 ml	Yes	5.8	No	Contains milk and egg white protein
	Toothpaste 75 ml			Yes	
	Alcohol free mouth rinse 300 ml			Yes	

**Table 3.** Shows examples of the current artificial salivary products available in the UK market. Adapted from Jawad *et al.*<sup>12</sup>

debris building up in the mouth. Their remineralizing contents, such as phosphate, calcium and fluoride, all contribute to the low cariogenic potential of these topical agents.<sup>10</sup>

A 2011 Cochrane review established that there was no strong evidence to support the efficacy of any one topical therapy for relieving symptoms of xerostomia.<sup>11</sup> Table 3 provides a list of examples of salivary substitutes currently available, including their dispensing form, fluoride content and whether they have any animal product within their ingredients.

## Treatment of oral conditions

### Dental caries

In the absence of saliva, patients with xerostomia are at a higher risk of developing caries. Therefore, education and instruction for patients on the importance of maintaining a diligent oral hygiene regimen is required. The

use of high-concentration fluoride, as previously mentioned, is recommended for the prevention of caries. If intervention is required, then restorations should be placed accordingly, following minimally invasive concepts.

The combination of xylitol chewing gum and chlorhexidine has also been shown to significantly reduce mutans streptococci, lactobacilli and yeasts in the saliva and is therefore a suitable adjunct in treatment.<sup>13</sup>

### Oral candidiasis

Oral candidiasis is one of the most prevalent opportunistic infections that can affect the oral mucosa.<sup>14</sup> Patients with xerostomia are at a higher risk of acquiring this infection because of the diminished salivary content and flow rate. Saliva contains many antimicrobial proteins such as lactoferrin, immunoglobulins, lysozyme, lactoperoxidase and histatins.<sup>14</sup> These proteins demonstrate antifungal activity and there is some evidence to suggest that

salivary IgA may inhibit the oral adhesion of *Candida albicans*.<sup>14</sup> Furthermore, as a result of a lowered salivary flow rate, and increase in *Candida* colony count, older patients have a higher risk for developing atrophic glossitis.<sup>15</sup>

The pharmacological treatment of candidiasis is generally either topical or systemic. Topical agents include, but are not limited to:<sup>16</sup>

- Nystatin can be dispensed as a suspension 100,000 units four times per day for 7 days and continued for 48 hours after the lesion has resolved.<sup>17</sup> It is important that clinicians note the cariogenic nature of nystatin due to its sugar content.
- Miconazole is prescribed as an oral gel 2.5 ml four times per day for at least 7 days after lesions have healed, or symptoms have cleared.<sup>17</sup>

The following drug can be prescribed as a systemic medication:<sup>16</sup>

- Fluconazole can be provided as a 50-mg daily tablet for 7–14 days.<sup>17</sup>

Clinicians should be aware of possible drug interactions. For example, the anticoagulant effect of warfarin can be enhanced with both miconazole and fluconazole. The British National Formulary gives a full list of interactions.<sup>18</sup>

### Prostheses

Patients who wear dentures should take them out every night, and ensure that they are not only cleaned, but rinsed, such as hexetidine (Oraldene, McNeil Products Ltd, High Wycombe) are used to penetrate areas where a brush does not adequately clean, or the dentures are submerged in chlorhexidine 0.12% as a disinfection solution.<sup>18,19</sup>

Patients who are affected by reduced salivary secretion and xerostomia find wearing complete dentures, in particular in the maxillary arch, very challenging owing to the lack of stability and retention caused by a deficiency in saliva. For dentures, which are poorly fitting, adjustment, relining or remake is advised. For dentures that fit accordingly, the use of denture adhesive has been shown to have a positive impact on the average retentive forces in patients with xerostomia.<sup>20</sup> Denture adhesives have been shown to have the highest retentive capability up to 1 hour post application.<sup>20</sup>

When denture adjustment, relining or adhesives are not suitable, then clinicians should consider whether the patient is a suitable candidate for an implant-borne prosthesis. Although there is limited research published on the efficacy of dental implants in patients with xerostomia, studies<sup>21,22</sup> have reported 84% and 88.4% success rates with this treatment modality at 2- and 4-year follow-ups.

## Increasing salivary flow

### Sialogogues

Functional salivary glands can be stimulated with the use of medication that has parasympathomimetic activity.<sup>23</sup> Sialogogues such as pilocarpine (mainly used for SS), bethanechol and cevimeline (the latter is not licensed in the UK) are cholinergic agonists with known predominant muscarinic action that can lead to an increase in saliva secretion.<sup>24</sup> These drugs act at the muscarinic–cholinergic receptors, which are found

in salivary glands.<sup>25</sup> They are not suitable for patients with other comorbidities and are often poorly tolerated owing to unpleasant side effects, such as sweating, diarrhoea and headaches. These medications should only be prescribed in a specialist setting.

### Acupuncture

Acupuncture is complementary and alternative medicinal technique that has more recently gained popularity among patients with xerostomia. It involves the insertions of a thin solid needle into intra- or subdermal loci for relief of symptoms.<sup>26</sup> Hypotheses supporting the use of acupuncture for increasing salivary secretion involve the stimulation of the parasympathetic and sympathetic nervous systems by neuronal activation.<sup>26</sup> Acupuncture is a low-risk therapy that suitably qualified clinicians can administer.

More research is required into its effectiveness as a therapy for xerostomia in the long term. Although a 2013 Cochrane review<sup>27</sup> indicated a small increase in saliva production, the evidence was of low quality.

### Electrostimulation devices

A 2013 Cochrane review assessed the use of an electrostimulation device compared to a placebo to see whether this non-pharmacological intervention stimulated saliva production.<sup>27</sup> Two studies on participants with Sjögren's syndrome were reviewed. No difference was reported at the end of a 4-week period and it was concluded that there was insufficient evidence to determine the effects of electrostimulation on saliva production.<sup>27</sup>

### Products containing olive oil, betaine and xylitol

The use of olive oil, betaine and xylitol have shown to be safe and effective methods for relieving symptoms associated with xerostomia, especially in patients in whom the underlying cause is polypharmacy.<sup>28</sup> These topical agents are available in mouthwash, toothpaste gel and spray preparations. Betaine is an amino acid that can maintain humidity and protect the oral cavity from irritation.<sup>29</sup> Olive oil inhibits bacterial growth and decreases the effects of mucus produced by a lack of saliva.<sup>30</sup> Xylitol (sugar-free) has proven effective against dental caries as well as stimulating salivary flow rate. It is important to note that studies have

shown controversial results in relation to the long-term increase in salivary flow and stimulation associated with chewing xylitol gum, notwithstanding its reported beneficial influence on oral health.

## Referral to secondary care

Many patients presenting with xerostomia can be managed in primary care with a focus on prevention and treatment. Referral to an oral medicine specialist should be considered if there is any suggestion that the patient's oral dryness is iatrogenic, or due to connective tissue or infectious salivary gland disease. Dental health professionals are well placed for the identification of potential underlying systemic conditions, which may be the primary cause of the presenting xerostomia.

Communication and multidisciplinary management with other healthcare providers may be necessary to ensure holistic patient care is provided.

## Conclusion

Early detection, diagnosis and appropriate management of xerostomia is required to prevent certain oral consequences, such as dental caries, from occurring and to aid the patient in reducing their symptoms when they arise. Reassurance, close monitoring and timely referral when necessary will ensure that the patient receives optimum care.

### Compliance with Ethical Standards

**Conflict of Interest:** The authors declare that they have no conflict of interest.

**Informed Consent:** Informed consent was obtained from all individual participants included in the article.

### References

- Challacombe SJ, Osailan SMPG. Clinical scoring scales for assessment of dry mouth. In: Carpenter G (ed.) *Dry Mouth*. Berlin: Springer, 2015; **119**–132.
- Thomson WM, van der Putten GJ, de Baat C *et al*. Shortening the xerostomia inventory. *Oral Surg Oral Med Oral Pathol Oral Radiol Endo* 2011; **112**: 322–327. <https://doi.org/10.1016/j.tripleo.2011.03.024>
- King's College London. The Challacombe scale. Available at: [www.challacombescale.co.uk/index](http://www.challacombescale.co.uk/index).

- html (accessed November 2022).
4. Ching AS, Ahuja AT. High-resolution sonography of the submandibular space: anatomy and abnormalities. *AJR Am J Roentgenol* 2002; **179**: 703–708. <https://doi.org/10.2214/ajr.179.3.1790703>
  5. French K, Fleming C, Bell C, Staines K. Labial gland biopsy: shared care, medicolegal and surgical considerations. *Oral Surgery* 2019; **12(3)**: 189–197
  6. Fisher BA, Jonsson R, Daniels T *et al*; Sjögren's histopathology workshop group (appendix) from ESSENTIAL (EULAR Sjögren's syndrome study group). Standardisation of labial salivary gland histopathology in clinical trials in primary Sjögren's syndrome. *Ann Rheum Dis* 2017; **76**: 1161–1168. <https://doi.org/10.1136/annrheumdis-2016-210448>
  7. Agha-Hosseini F, Moosavi MS. An evidence-based review literature about risk indicators and management of unknown-origin xerostomia. *J Dent (Tehran)* 2013; **10**: 273–282.
  8. NICE. Dental checks: intervals between oral health reviews. CG19. Available at: [www.nice.org.uk/guidance/cg19/chapter/Introduction](http://www.nice.org.uk/guidance/cg19/chapter/Introduction) (accessed November 2022).
  9. NHS England. Delivering better oral health: an evidence-based toolkit for prevention. 2021. Available at: [www.gov.uk/government/publications/delivering-better-oral-health-an-evidence-based-toolkit-for-prevention](http://www.gov.uk/government/publications/delivering-better-oral-health-an-evidence-based-toolkit-for-prevention) (accessed November 2022).
  10. Cassolato SF, Turnbull RS. Xerostomia: clinical aspects and treatment. *Gerodontology* 2003; **20**: 64–77. <https://doi.org/10.1111/j.1741-2358.2003.00064.x>
  11. Furness S, Worthington HV, Bryan G *et al*. Interventions for the management of dry mouth: topical therapies. *Cochrane Database Syst Rev* 2011; **(12)**: CD008934. <https://doi.org/10.1002/14651858.CD008934.pub2>
  12. Jawad H, Hodson NA, Nixon PJ. A review of dental treatment of head and neck cancer patients, before, during and after radiotherapy: part 2. *Br Dent J* 2015; **218(2)**: 69–74. <https://doi.org/10.1038/sj.bdj.2015.29>
  13. Simons D, Kidd EA, Beighton D, Jones B. The effect of chlorhexidine/xylytol chewing-gum on cariogenic salivary microflora: a clinical trial in elderly patients. *Caries Res* 1997; **31**: 91–96. <https://doi.org/10.1159/000262382>
  14. Nadig SD, Ashwathappa DT, Manjunath M *et al*. A relationship between salivary flow rates and *Candida* counts in patients with xerostomia. *J Oral Maxillofac Pathol* 2017; **21**: 316. [https://doi.org/10.4103/jomfp.JOMFP\\_231\\_16](https://doi.org/10.4103/jomfp.JOMFP_231_16)
  15. Garcia-Cuesta C, Sarrion-Pérez MG, Bagán JV. Current treatment of oral candidiasis: a literature review. *J Clin Exp Dent* 2014; **6**: e576–582. <https://doi.org/10.4317/jced.51798>
  16. British National Formulary. 2022. Available at: <https://bnf.nice.org.uk> (accessed November 2022).
  17. British National Formulary. Fluconazole. Interactions. 2022. Available at: <https://bnf.nice.org.uk/interactions/fluconazole/> (accessed November 2022).
  18. Akpan A, Morgan R. Oral candidiasis. *Postgrad Med J* 2002; **78**: 455–459. <https://doi.org/10.1136/pmj.78.922.455>
  19. British National Formulary. Miconazole. Interactions. 2022. Available at: <https://bnf.nice.org.uk/interaction/miconazole-2.html>
  20. Bogucki ZA. Denture adhesives' effect on retention of prostheses in patients with xerostomia. *Adv Clin Exp Med* 2018; **27**: 1247–1252. <https://doi.org/10.17219/acem/69078>
  21. Isidor F, Brøndum K, Hansen HJ *et al*. Outcome of treatment with implant-retained dental prostheses in patients with Sjögren syndrome. *Int J Oral Maxillofac Implants* 1999; **14**: 736–743.
  22. Payne AG, Lownie JF, Van Der Linden WJ. Implant-supported prostheses in patients with Sjögren's syndrome: a clinical report on three patients. *Int J Oral Maxillofac Implants* 1997; **12**: 679–685.
  23. Chainani-Wu N, Gorsky M, Mayer P *et al*. Assessment of the use of sialogogues in the clinical management of patients with xerostomia. *Spec Care Dentist* 2006; **26**: 164–170. <https://doi.org/10.1111/j.1754-4505.2006.tb01719.x>
  24. Gorsky M, Epstein JB, Parry J *et al*. The efficacy of pilocarpine and bethanechol upon saliva production in cancer patients with hyposalivation following radiation therapy. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2004; **97**: 190–195. <https://doi.org/10.1016/j.tripleo.2003.08.031>
  25. Fife RS, Chase WF, Dore RK *et al*. Cevimeline for the treatment of xerostomia in patients with Sjögren syndrome: a randomized trial. *Arch Intern Med* 2002; **162**: 1293–1300. <https://doi.org/10.1001/archinte.162.11.1293>. PMID: 12038948.
  26. Assy Z, Brand HS. A systematic review of the effects of acupuncture on xerostomia and hyposalivation. *BMC Complement Altern Med* 2018; **18**: 57. <https://doi.org/10.1186/s12906-018-2124-x>
  27. Furness S, Bryan G, McMillan R *et al*. Interventions for the management of dry mouth: non-pharmacological interventions. *Cochrane Database Syst Rev* 2013; **2013(9)**: CD009603. <https://doi.org/10.1002/14651858.CD009603.pub3>
  28. Ship JA, McCutcheon JA, Spivakovsky S, Kerr AR. Safety and effectiveness of topical dry mouth products containing olive oil, betaine, and xylytol in reducing xerostomia for polypharmacy-induced dry mouth. *J Oral Rehabil* 2007; **34**: 724–732. <https://doi.org/10.1111/j.1365-2842.2006.01718.x>
  29. Rantanen I, Nicander I, Jutila K *et al*. Betaine reduces the irritating effect of sodium lauryl sulfate on human oral mucosa *in vivo*. *Acta Odontol Scand* 2002; **60**: 306–310. <https://doi.org/10.1080/00016350260248292>
  30. Pretty IA, Gallagher MJ, Martin MV *et al*. A study to assess the effects of a new detergent-free, olive oil formulation dentifrice *in vitro* and *in vivo*. *J Dent* 2003; **31**: 327–332. [https://doi.org/10.1016/s0300-5712\(03\)00052-6](https://doi.org/10.1016/s0300-5712(03)00052-6)