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# Clinical and laboratory assessment of nutrition status in dental practice

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There is a dynamic, two-way relationship between diet/nutrition and oral health: a balanced diet with adequate energy and nutrients is essential for oral health, and the condition of the oral cavity and surrounding structures can impact diet and nutritional well-being. In healthy individuals, "the complex interplay involving the teeth, jaws, muscles, tongue and salivary glands is accomplished with ease and enjoyment" [1], allowing an individual to select and consume a balanced diet.

As elucidated in the American Dietetic Association's position on nutrition and oral health [2], nutrition is an integral component of oral health care, and the role of the dental professional includes screening for nutrition risk, diet education, and referral to a registered dietitian as needed for medical nutrition therapy. Healthy People 2010 [3] and research [4–7] support the recognition that oral health is integral to overall health. The United States Surgeon General's Report on oral health [7] reinforced the idea that because the oral cavity is the beginning of the gastrointestinal tract, diseases and limitations of the oral cavity can affect the ability to ingest, masticate, and swallow foods and fluids, which in turn could potentially affect overall nutrition status and, ultimately, systemic health.

## Nutrition screening in dental practice

It is incumbent upon dietetics and dental professionals to conduct baseline evaluations of oral and nutrition status, provide appropriate education, and refer patients accordingly to the appropriate health professional [2]. The synergistic relationship between diet/nutrition and integrity of the oral cavity and its potential impact on general health support

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the need for nutrition screening as a routine part of dental care [4,8]. Fig. 1 depicts the balance between diet/nutrition and oral health and disease. Nutrition and oral health can have a significant impact on general health [2,5,8,9]. Compromised diet intake can lead to decreased intake of essential nutrients and subsequent malnutrition, increasing the risk for systemic and oral disease. Although several vitamin, mineral, and other dietary supplements have been promoted for "optimal oral health and well-being," they are unnecessary and potentially harmful to prescribe before determining the presence of nutrition risk and potential nutrient deficits.

Nutrient deficiencies result from an imbalance of supply and demand, that is, when the supply of nutrients is inadequate to meet the demands of the individual. The dental professional is likely to note this imbalance when the supply is low because of a compromise in oral integrity that compromises dietary intake. A nutrition screening process can detect this imbalance. The need for nutrition screening is evident in general dental practice and in specialty practices including pedodontics, periodontics, oral surgery, oral medicine, orthodontics, and prosthodontics.

## Nutrition-risk screens

Recognized screening and assessment tools for nutrition status evaluation include the Subjective Global Assessment [10], the Nutrition Screening Initiative "DETERMINE" checklist for older adults [11], and other disease and life stage–specific tools. There are no published, validated tools for nutrition screening of dental patients. This article addresses nutrition screening and assessment strategies for use in dental practice.

Nutrition screening, at a minimum, includes subjective statements relative to diet, oral health, and weight history, as well as objective assessment of anthropometric measurements and condition of the oral cavity. The extent to which laboratory data and other components are used is dependent, in part, on the type of dental practice and the overall health and disease history of the patient. Patients with complex medical histories taking multiple medications require a more extensive physical and laboratory assessment.

Nutrition risk factors are defined as "characteristics that are associated with an increased likelihood of poor nutritional status" [11]. Oral health nutrition risk factors are outlined in Box 1. Nutrition risk is based on the type and extent of risk factors present. The elderly patient who lives alone, has lost 10 lb in 6 months, and has difficulty chewing is at significant risk, as is the 35-year-old woman who is HIV positive and presents with candidiasis and periodontitis. It is always prudent to refer any patient for whom a practitioner suspects nutrition/diet concerns to a registered dietitian for medical nutrition therapy.

The outcomes of nutrition-risk screening in the dental setting are based on individual needs and may include:

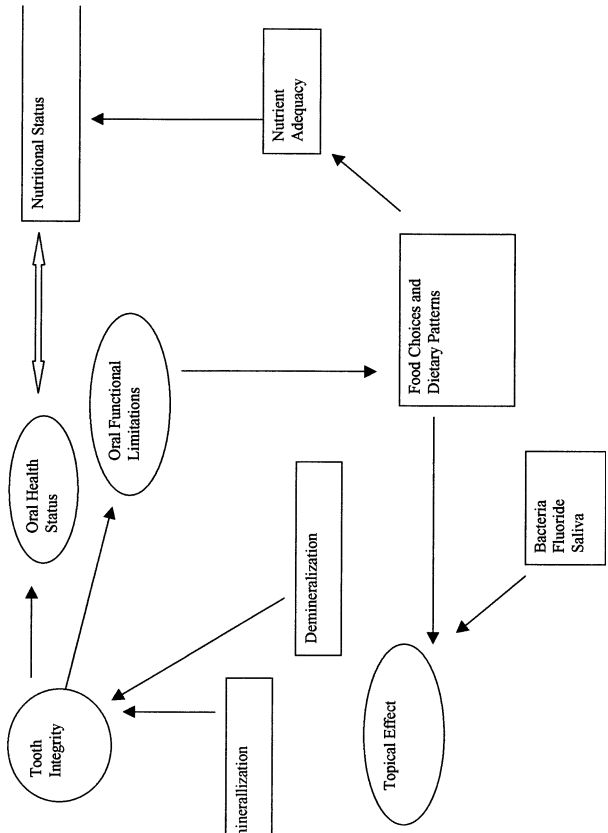


Fig. 1. Diet and dental health. (*From* DePaola DP, Mobley C, Touger-Decker R. Nutrition and oral medicine. In: Berdanier C, editor. Handbook of nutrition and food. New York: CRC Press; 2001. p. 1113–34; with permission.)

**Box 1. Oral nutrition risk factors**

Acute/chronic disease
Biting/chewing/swallowing difficulty
Poverty
Polypharmacy
Dental procedures altering ability to eat a usual diet
Oral infections
Ulcerations/lesions
Cranial nerve disorders
Inadequate diet
Altered or painful taste
Unintentional weight change
Substance abuse
Extensive caries
Oral surgeries
Xerostomia
Orofacial pain

- Basic diet evaluation and education by the dental professional to meet oral and nutritional health needs
- Prescription for oral supplements (name, volume, frequency)
- Referral to social services for food/supplement resources in community
- Referral to a registered dietitian for nutrition consultation and medical nutrition therapy

## Patient history

Patient history is an important component of nutrition evaluation. Past medical history will reveal information about acute, chronic, and terminal diseases that may impact oral and nutritional well-being. Systemic diseases associated with nutrition risk are listed in Box 2. There are over 100 systemic diseases with oral manifestations [7]. In addition to asking patients about their past medical/surgical and drug history, diet and nutrition-risk evaluation questions may also be asked. Suggested questions used in dental practice are listed in Appendix 1.

History of unintentional weight change may signal potential nutrition deficits, lack of money for food, or systemic disease. A weight change of greater than 10 lbs in less than 6 months is considered a significant risk factor in any individual [12]. Weight loss is characterized by loss of body fat stores and lean body mass. Obtaining a patient weight at the first appointment gives the practitioner a baseline for comparison to a self-reported weight history and a base for future reference. Serial weights should be recorded for

**Box 2. Systemic diseases associated with nutrition risk**

Arthropathies
Cancer
Cardiovascular disease
Diabetes mellitus
End-stage renal disease
HIV infection/AIDS
Inflammatory bowel disease
Lupus
Megaloblastic anemia
Mucocutaneous diseases
Orofacial pain
Osteoporosis
Rheumatoid arthritis
Sjögren's syndrome
Vesiculobullous diseases

patients with weight loss, HIV/AIDS, cancer, diabetes, autoimmune diseases, or other systemic diseases. The role of weight in assessment and calculations is discussed further in the section on anthropometric evaluation.

*Medical history*

Medical history will reveal individual information about acute or chronic diseases and immunologic disorders that are risk factors in patients with concurrent oral/dental problems affecting their ability to consume their usual diet. The 65-year-old woman whose chief complaint is "I can't chew my food" is at significant nutrition risk if she has type 2 diabetes mellitus. Oral manifestations associated with diabetes often occur because diabetes is out of control, and the cause of poor control may be poor diet. These manifestations, including periodontal disease, dysguesia, increased caries risk, candidiasis, burning tongue, and poor wound healing (particularly when blood sugars are elevated) may, in turn, impact appetite, eating ability and, finally, oral intake [6]. Neuropathies and opportunistic microbial infections in the oral cavity affect oral health, nutrition status and, inevitably, diabetes control.

Autoimmune diseases such as pemphigus vulgaris, rheumatoid arthritis, lupus, and Sjögren's syndrome increase nutrition risk by virtue of the oral and facial sequellae of the disease and the medications used to manage disease [4,8]. Intraoral and extraoral lesions associated with pemphigus vulgaris can impair intake and oral sensory perception during periods of active disease. The xerostomia associated with Sjögren's syndrome increases risk for dental

caries, periodontitis, and oral fissures, which may make eating difficult or painful [8]. Temporomandibular joint pain may result in limited opening of the mouth and compromised masticatory function, which may be evident in individuals with rheumatoid arthritis. Arthropathies have associated medication side effects; however, joint-related effects may compromise eating ability. Steroids used to manage vesiculobullous and other diseases increase nitrogen (protein) and calcium losses, thus increasing needs. All of these factors that the dental professional may routinely evaluate provide evidence of nutrition-risk status.

Head, neck, and oral cancer affect nutrition and oral health status [8]. Surgeries to remove malignant tumors in the oral cavity may have severe functional effects on eating ability. Radiation to the oral cavity can destroy taste and the quality and quantity of saliva. Chemotherapy can cause anorexia, nausea, and vomiting, ultimately compromising nutrition status.

Individuals with HIV infection or AIDS are at increased risk of oral infections and disease manifestations that impact functional and sensory functions of the oral cavity [13]. Oral complications and malnutrition may occur secondary to the disease process and associated gastrointestinal, metabolic, immune, pharmacologic, and psychosocial sequellae. Altered micronutrient metabolism may contribute to oral manifestations and subsequent malnutrition, further compromising oral integrity and the ability to combat infections. Nutrition screening by the dental professional is important, with a particular focus on the integrity of the oral cavity and on medications and their combined impact on oral function. A referral to a registered dietitian is routine in this population for medical nutrition therapy.

Osteoporosis is increasingly common in women (one in two women) and men (one in eight men) [14]. The relationship between osteoporosis and oral health is increasingly evident [15,16], particularly in reference to periodontal disease and implant surgery. The dental professional should be familiar with high-risk individuals and should question them about any history of osteoporosis and whether or not they have undergone screening or diagnostic evaluations. Risk factors for osteoporosis [14] include:

- Long-term (more than 1 month) steroid use
- Cushings syndrome, hyperparathyroidism, hyperthyroidism, end-stage renal disease
- History of organ transplants treated with cyclosporine and steroids
- Spinal cord injury
- Women who are perimenopausal or of small stature
- Family history of osteoporosis
- Prolonged low calcium intake combined with inactivity
- Prolonged lack of exposure to sunlight

Patients at risk for osteoporosis should be given referrals for a dexascan to determine bone density and the presence of osteoporosis and for medical

nutrition therapy. Calcium supplements and other prescription medications may be needed to reduce risk or combat disease.

### *Medications and dietary supplements*

Medications can result in drug-nutrient, drug-supplement, and drug-drug interactions and can influence nutrient intake, nutrient absorption, and oral health. Over 400 medications including antihistamines, diuretics, antianxiety agents, and antidepressants cause xerostomia [17]. Xerostomia can impact sensory perception of taste, the functional ability to swallow, and can increase the risk of oral infectious processes including dental caries. Patients should be questioned regarding prescription and over-the-counter medication use, drug form, frequency of use, and side effects they may experience. Herbal supplements may alter metabolism of prescription medications and/or affect the oral cavity. Echinacea may interfere with the actions of immunosuppressing medications secondary to its immune-enhancing effects [18,19]. Ephedra, or ma huang, is a dietary supplement found in weight-loss products and ergogenic aids. Its principal alkaloids are ephedrine and pseudoephedrine [19]. When epinephrine and ephedrine-containing supplements are taken simultaneously, the resultant stimulatory effects, including increased blood pressure and heart rate and central nervous system stimulation, may be additive (Phillip Gregory, Pharm D, personal communication, April 2002). The impact of the combination is difficult to estimate because it would depend on how much of each agent is taken and the actual ephedrine content of the ephedra-containing supplement consumed. According to the *Natural Medicines Comprehensive Database* [19], ephedrine has a short half-life (2.5–3.6 hours); the recommendation to withhold consumption of ephedrine-containing supplements for 24 hours prior to a dental procedure in which a local anesthetic with epinephrine would be administered would therefore be prudent (Phillip Gregory, Pharm D, personal communication, April 2002). The article by Rigassio-Radler in this issue provides more detail on this subject. The dentist should ask about use of complementary and alternative medicines (such as herbal, botanical, or nutrient supplements) and their form, dosage, and frequency. The *Physician Desk Reference for Herbal Supplements* [20], the *Natural Medicines Comprehensive Database* [19], or the *Commission E Monographs* [18] can be used to evaluate potential symptoms and side effects of these dietary supplements.

## Physical assessment of nutrition status

### *Anthropometric evaluation*

There are several Web-based programs available to calculate weight change and body mass index (BMI). The United States Department of

Agriculture's Interactive Healthy Eating Index [21] provides access to a computerized nutrient analysis program and anthropometric evaluation. BMI is defined as the ratio of height to weight. It is used in the assessment of obesity and compares body size to a standard. BMI can be determined using the equation in Fig. 2. Although BMI does not indicate the location of body fat or distinguish, for example, between body fat and the high lean body mass of a muscle builder, it is a useful screen for overweight and obesity in normal, healthy individuals.

Fig. 2 shows the formulas for calculating weight change, desirable weight, and BMI. If a patient does not know his or her usual weight, then desirable weight can be used to calculate percent desirable weight. Weight alone does not differentiate between body fat and muscle mass. BMI provides an estimation of weight in proportion to height [12]. To differentiate between weight due to body fat versus muscle, bioelectrical impedance analysis or other methods that measure body fat and muscle mass are needed.

Sheiham et al [22] studied the relationship between BMI and oral health status in a population of elderly persons in Great Britain. Their findings demonstrated a relationship between dentate status and BMI. The results showed that elderly persons with less than 21 natural teeth were "on average more than three times more likely to be obese than those with 21–32 teeth" and elderly persons with less than 11 teeth were "significantly more likely to

Wt change is calculated based on usual body wt:

$$\frac{\text{today's weight}}{\text{usual weight}} \times 100 = \%\text{weight change}$$

EX: $\frac{\text{today's wt} = 50\ \text{lbs}}{\text{usual wt} = 100\text{lbs}} \times 100 = -50\%$

Current (today's) wt < usual wt = negative wt change.
Current wt >usual wt = positive weight change.

Ranges of Desirable Height - Weight for Adults: Rule of Thumb:
Men = 106 lbs for first 5 feet + 6lbs/inch
ex: 5'6" man = 106 + (6 inches x 6lbs/inch) = 106 + 36 = 142lbs +/-10% desirable wt

Women = 100 lbs for first 5 feet + 5lbs/inch
ex: 5'2" woman = 100lbs + (2 inches x 5lbs/inch) = 100lbs + 10 = 110lbs +/-10%
+/-10% = based on frame size weight range may be 10% greater or less than the calculated wt

Body Mass Index

$$\frac{\text{Body weight in kilograms (kg)}}{(\text{height in meters})^2}$$

OR:

$$\text{Weight (in pounds)} \times 703 \text{ divided by } (\text{height in inches})^2$$

Fig. 2. Formulas for weight and body mass index calculation.

be underweight than those with 11 or more teeth.'' Additional research is needed in larger socioeconomic and age populations to determine the relationship between BMI, dentate status, and occlusal status. The number of pairs of opposing teeth may be of greater importance for mastication than dentate status alone.

*Intraoral and extraoral examination*

Each of the routine components of the dentist's oral examination can be used as part of the nutrition-risk screening process. Intraoral and extraoral physical examination findings, including functional assessment of the cranial nerves, occlusal and dentition status, quality and quantity of saliva, presence of oral lesions or ulcerations, and any infections, can have diet and nutrition implications. The nutrition-risk component of an oral examination should identify existing or potential problems at one or more of the following four levels:

1. Oral manifestations of a nutritional disorder
2. Oral manifestations of a systemic disease that impacts diet and nutritional status
3. Local oral conditions interfering with ingestion, mastication, swallowing ability, taste, and saliva
4. Dietary influences on the oral cavity and their contribution to oral diseases

Tables 1 and 2 detail the nutrition risk factors to consider in head, neck, and oral examinations and the abnormal oral and physical examination findings associated with nutrition risk. Findings must be evaluated in light of patient subjective reports, medical history, and the existing or potential effect on patient ability to eat and subsequent nutrition risk. The clinician must examine symptoms to determine the cause so that the symptom in addition to the precipitating disease or etiology is treated. Abnormal oral findings associated with local and systemic diseases and nutritional causes are outlined in Table 2. Oral ulcerations may be due to nutrient deficiencies and, depending on their location and size, they may severely impact a patient's eating comfort and ability. Oral symptoms listed in Table 2 may be painful and interfere with eating ability. Referral for medical nutrition therapy by a registered dietitian may be indicated in order to improve patient eating comfort and the quality of their diet. In rare circumstances, enteral tube feeding may be indicated when patients cannot or will not consume an adequate oral diet.

Patients with difficulties biting, chewing, or swallowing may be at risk depending on the presence of other risk factors and the duration and severity of the problem [5,9,23,24]. Identification of nutrition risk in this type of patient signals the need for simple guidelines on modification of food form and consistency to promote improved diet and subsequent nutritional well-being. Individuals receiving a new full denture are at nutrition risk by

Table 1
Nutrition risk factors to consider in physical examination

| Body area | Nutrition risk factors | Nutrition implications |
|---|---|---|
| Hair | Dull, shedding, easily pluckable | Generalized protein calorie malnutrition |
| Face | Malar pigmentation (dark skin over cheeks and under eyes) | Niacin, B vitamins |
| | Bitemporal wasting | Malnutrition |
| | Nasolabial seborrhea | Niacin, riboflavin, $B_6$ |
| | Edematous | Protein deficiency |
| | Moon face | Corticosteroid impact |
| | Lack of color | Inadequate Fe++, undernutrition |
| Eyes | Pale eye membranes | Inadequate Fe++ |
| Lips | Cheilosis (red/swelling) | Inadequate niacin, riboflavin |
| | Angular fissures | Inadequate niacin, $B_6$, riboflavin, Fe++ |
| Gingivae | Spongy, bleeding, abnormal redness | Inadequate vitamin C |
| Tongue | Glossitis (red, raw, fissured) | Inadequate folate, niacin, riboflavin, Fe++, $B_6$, $B_{12}$ |
| | Pale, atrophic, smooth/slick (filiform papillary atrophy) | Inadequate Fe++, $B_{12}$, niacin, folate |
| | Magenta color | Inadequate riboflavin |
| Nails | Spoon shaped, brittle, ridged | Inadequate Fe++ |
| Back | Pony prominances along shoulder girdle | Malnutrition |
| Muscles | Tendons prominent to palpation | Malnutrition |

virtue of a change in masticatory apparatus and need education on diet modification during the initial fitting and adjustment phases. If other risk factors are present, however, a referral to a registered dietitian for medical nutrition therapy may be indicated.

Implications of impaired cranial nerve function for compromised diet and nutrition status are listed in Table 3. Patients should be carefully questioned as to changes in their usual diet and their ability (including pain) to taste, bite, chew, and swallow individual foods. Although the dental professional is likely very familiar with a cranial nerve examination, the factors listed in Table 3 provide insight into diet and nutrition implications of examination parameters.

Individuals with moderate-to-extensive caries are at nutrition risk and should be seen by a dental professional for diet/nutrition evaluation and education. Individuals with soft-tissue lesions, oral pathologies, or orofacial pain/disorders interfering with the ability to eat, or individuals having examination findings suggestive of nutrition deficits are clearly at nutrition risk and should be referred to a registered dietitian for medical nutrition therapy.

## Laboratory tests to assess nutrition risk

Diagnostic tests including hematologic evaluations provide insight into possible causes of oral symptoms, oral diseases, and other systemic diseases. The complete blood count provides critical values for assessing immune

Table 2
Abnormal oral findings: associated local and systemic diseases and nutrition considerations

| Clinical feature | Associated finding | Associated disorders | Nutritional considerations |
|---|---|---|---|
| Xerostomia | Dental caries, candidiasis, dysphagia, dysgeusia, burning mouth/tongue | Drug-induced xerostomia, head and neck irradiation, Sjögren syndrome, diabetes | Increase fluids, minimize cariogenic foods, modify food consistency and flavoring, evaluate glucose control in diabetes |
| Burning mouth/ tongue | May be associated with mucosal erythema/atrophy, glossitis | Anemia, diabetes, candidiasis | Determine etiology of anemia (iron, folate, $B_{12}$), modify food consistency and flavoring, evaluate glucose control |
| Angular cheilitis | Dry, cracked, fissured corner of the mouth | Dehydration, anemia, ill-fitting dentures (drooling) | Determine etiology, possible riboflavin deficiency |
| Candidiasis | White and/or red removable patches on the oral mucosa | Impaired immunity, diabetes | Determine etiology, modify food consistency, temperate non spicy foods |
| Difficulty chewing | Partial or complete edentulism, poor occlusion, ill-fitting dentures | Cranial nerve disorders | Determine etiology, modify food consistency to chopped non sticky foods, referral for medical nutrition therapy |

*Data from* Touger-Decker R, Sirois S. Physical assessment of the oral cavity. Support Line 1996;18(5):1–6.

Table 3
Superficial cranial nerve examination findings associated with nutrition risk

| Nerve | Function | Abnormality |
|---|---|---|
| I Olfactory | Olfaction | Altered, impaired, or absent sense of smell |
| V Trigeminal | Sensory perception to mucocutaneous structures of face, scalp, mouth, nose, teeth | Impaired or altered sensation of facial skin or oral mucosa |
| | Masticatory muscles | Impaired masticatory ability, asymmetry on jaw opening/closing |
| VII Facial | Muscles of facial expression | Facial asymmetry, partial or complete facial palsy (paralysis) |
| | Taste anterior two thirds of tongue | Altered, impaired, or absent taste perception |
| IX Glossopharyngeal | Swallowing | Altered or impaired swallowing |
| | Taste posterior one third of tongue | Altered or impaired taste perception |
| X Vagus | Swallowing | Altered or impaired swallowing, dysphagia |
| | Gastrointestinal motility | Reflux, dysphagia, dyspepsia, dumping syndrome, gastroparesis, achlorhydria |
| XII Hypoglossal | Tongue muscles | Deviation of tongue, dysphagia, dysarthria |

response, iron deficiency anemia, and other disorders. Table 4 outlines normal values and their interpretation for the complete blood count. The laboratory data provides values for electrolytes, serum proteins, trace elements, glucose, lipids, and organ function. Select values, normal ranges, and definitions are listed in Table 5.

Serum albumin reflects visceral protein status and is often used in hospitalized patients as a screening parameter to determine nutrition risk. Albumin, however, has a half-life of approximately 20 days [25], so is not reflective of day-to-day changes in protein nutriture or nutrition status. Hydration status and liver disease also affect the validity of serum albumin as a nutrition-risk assessment parameter. More immediate parameters used to assess protein status include prealbumin and retinal binding protein, which have half-lives of 2 to 3 days and less than 1 day, respectively [25]. These measures are expensive, are influenced by several nonnutrition parameters, and are typically reserved for patients in the hospital or in an inpatient care setting.

Depending on the patient's medical history or presenting symptoms, other laboratory data may be needed. Hemoglobin A1C should be evaluated in individuals with diabetes mellitus. Hemoglobin A1C provides a measure of blood glucose control over time as opposed to fasting blood glucose or urine glucose values, which provide a measure of glucose at a single point in time. In individuals with diabetes and those with a history of hyperlipidemia, serum lipid levels (cholesterol, LDL cholesterol, HDL cholesterol, triglycerides) should be reviewed [26]. These values contribute to the health assessment of the patient and, when combined with diet and weight status, provide a measure of the individual's overall health attitude. Individuals who present with systemic symptoms and oral manifestations associated with autoimmune diseases such as Crohn's disease or pemphigus vulgaris should be referred for the appropriate diagnostic tests and to their physician. In the individual with HIV infection or AIDS, the clinician will want to review tests reflecting immune status. In the individual with end-stage renal disease, values reflective of renal function including blood urea nitrogen, creatinine, and electrolytes (sodium, potassium) will be important to review as well as the complete blood count for hematocrit and hemoglobin.

Dental practitioners in hospitals or other inpatient settings may find the above parameters available and useful in determining nutrition risk. In the ambulatory care dental setting, however, it is unlikely the practitioner will have access to anything other than a complete blood count and possibly blood glucose and electrolyte values. It is incumbent upon the practitioner to contact the patient's physician if access to laboratory test results are needed.

## Diet and nutrition evaluation: diet versus nutrients

As part of the nutrition screening process, diet and nutrition evaluation may be brief and limited to asking open-ended questions such as those

Table 4
Complete blood count

| Parameter | Normal range | Interpretation |
|---|---|---|
| Hgb | Male: 13–16 g/100 mL Female: 12–15 g/100 mL | Concentration of Hgb (protein-iron compound) in the blood |
| Hct | Male: 42%–50% Female: 40%–48% | Percentile of packed RBC in total blood volume |
| WBC | 4.5–11.0 $mm^3$ | Immune response; leukopenia (WBC<4500) seen in patients with AIDS |
| Lymphocyte | 26%–43% | Represents 25% of WBC; count increases in infection |
| Mean corpuscular Hgb | 27–31 $\mu g$ | Hgb content in a RBC; Hgb:RBC |
| Mean corpuscular volume | 80–94 $\mu m^3$ | Average volume of each RBC; Hct:RBC |
| Mean corpuscular Hgb concentration | 32.63 | Concentration of Hgb/100 mL of RBC; Hgb:Hct |

*Abbreviations:* Hct, hematocrit; Hgb, hemoglobin; RBC, red blood cell count; WBC, white blood cell count.

Table 5
Laboratory data

| Parameter | Normal range | Definition |
|---|---|---|
| Serum sodium | 133–145 mEq/L | Serum concentration of sodium; primary ECF cation |
| Serum potassium | 3.5–5.0 mEq/L | Serum concentration of potassium primary ICF cation |
| Serum urea nitrogen | 5–20 mg/dL | Urea is the end product of protein metabolism; reflects serum concentration |
| Creatinine | 0.6–1.5 mg/100 mL | |
| Total protein | 6.0–8.4 g/100 mL | Total protein in serum; includes globulins and albumin |
| Albumin | 3.5–5.0 g/dL | Serum protein, half-life of 18–21 d; calcium bound that reflects visceral protein stores; maintains colloid oncotic pressure |
| Cholesterol | 120–200 mg/100 mL | Serum concentration of this lipid-soluble steroid |
| Blood glucose | 70–115 mg/dL | Serum concentration of glucose |
| Fasting blood glucose | 70–115 mg/dL | Serum concentration of glucose after a 12 h fast |
| Serum calcium | 8.5–11.0 mg/100 mL | Serum concentration of calcium |

*Abbreviations:* ECF, extracellular fluid; ICF, intracellular fluid.

marked with an asterisk in Appendix 1. Questions on functional limitations in eating can be paired with examination findings to determine the etiology of the eating difficulties and to treat accordingly as part of the dental treatment plan and with diet guidelines [22,23,27]. Questions on eating frequency and consumption of added sugars should be looked at with caries risk and oral hygiene practices to determine the diet education needed to reduce caries risk. Socioeconomic questions regarding food access and finances provide critical information about the individual's status that can be managed with a referral for social services [28]. Those questions related to osteoporosis risk should be reviewed in light of risk factors for the disease and oral examination findings; appropriate referrals for further evaluation by a physician of osteoporosis risk should be provided. These simple screening questions may be part of a self-administered questionnaire that the dental professional then reviews with the patient in order to probe responses. These responses provide an overview of diet and nutrition risk and determine the need for further intervention. Although there is no objective measure to determine how many positive responses indicate nutrition risk, the dental professional should view findings in conjunction with other nutrition screening parameters and dental examination outcomes to determine presence and extent of risk.

More detailed diet evaluation should be provided for any patients determined to be at oral nutrition risk. In the dental office setting, this may include patients with extensive decay, those getting new dentures, individuals with oral lesions, or those with oral health–related eating difficulties. A diet recall—asking patients to recall everything they eat and drink on 1 to 2

typical days—provides a snapshot of a patient's eating habits. The dental professional should record specific foods and fluids consumed as meals and snacks, portion sizes, and eating frequency. Other strategies including a food diary or food frequency questionnaire have also been used. A food diary consists of asking a patient to record their intake at home for 3 to 5 days and return a complete diary to the dental professional. Although an accurately completed food diary would provide a more comprehensive picture of typical eating habits over time than the interviewer-administered dietary recall, food diaries returned by patients are typically incomplete. They often lack a full record of all meals and snacks, portion sizes, and condiments. To obtain a more accurate food diary, research studies employing this method will call patients on a daily basis, reviewing their recorded diary. This strategy is time-consuming and not realistic for a typical dental practice. Food frequency questionnaires, often employed by research studies, include a detailed listing of food groups and specific foods in varying portion sizes; individuals completing a food frequency questionnaire indicate how often in a day, week, or month (or sometimes year) they consume certain foods. These questionnaires are time-consuming and, for best results, should be administered by an interviewer. In regard to oral health assessment, food frequency questionnaires do not provide a measure of eating habits; that is, frequency of eating occasions or how often cariogenic foods are consumed. To be analyzed, food frequency questionnaires typically need to be submitted (with a fee) to an independent third party.

Thus, the diet recall (a recall of foods and fluids consumed on a weekday and weekend day) remains the most accessible dietary assessment tool for the dental office setting. Combined with the questions in Appendix 1, this method provides a general overview of the patient's eating habits and factors affecting diet intake. Assessment of the diet recall can be done through multiple ways. The most simple, office-based strategy is to convert the recall into to servings of foods within the Food Guide Pyramid. Taking an average of the 2 days (weekday and weekend day), the patient's Food Guide Pyramid intake is compared to the Food Guide Pyramid recommendations to determine diet adequacy. There are several food guide pyramids for children, adults, older adults, and cultural groups. These can all be found and downloaded from a federal Web site, www.nutrition.gov. The outcomes of the assessment can be reviewed with the patient to determine areas for improvement.

Several computer-based nutrient analysis programs also exist. The Interactive Healthy Eating Index [21], previously cited, is a free, federally supported program that provides computerized nutrient analysis of 24-hour dietary recalls. The report generated by this tool includes a diet assessment and recommendations. Dental school student doctors in the clinic setting (R. Touger-Decker, unpublished data; Connie Mobley, PhD, RD, San Antonio, Texas, personal communication, June 2002) and research studies on oral health and nutrition [24] have used this tool. More extensive computer-

ized analysis programs for analysis of multiday recalls include Food Processor [29] and Nutritionist Pro [30]. These programs start at about $500 and go up depending on the level of sophistication. All of the programs, including the Interactive Healthy Eating Index [21], are fairly simple to learn and use. It takes approximately 15 to 20 minutes to analyze a 2-day diet recall using one of the computer-based programs. The difference between the simple food guide pyramid assessment and the computerized assessment is the level of diet evaluation provided. The food guide pyramid assessment is quick but only gives an evaluation of food groups consumed in comparison to a standard. The computerized assessment also details calories, macronutrient, and micronutrient intake, as well as cholesterol and dietary fiber. The level of assessment used should be based on the type of dental practice and level of detail required.

The outcome of the diet assessment can be used by the dental practitioner to guide the patient to make appropriate food choices for optimal oral health, wound healing, or eating due to altered oral function. The dental professional can provide diet and nutrition education relative to oral and overall health. More extensive diet evaluation and counseling for disease or weight management should be referred to a registered dietitian, the credentialed nutrition professional.

## Summary

There is a dynamic, two-way relationship between nutrition status and local oral health/systemic disease. Functional alterations in the oral cavity can impact the ability to ingest and swallow a typical diet. Nutrition status may influence disease progression and recovery from infection and surgery. Malnutrition and individual nutrient deficiencies can affect tissue integrity and muscle function.

The benefits of a nutrition screening program in dental practice are many. First and foremost, it provides another critical component of the comprehensive health evaluation of the patient. Other positive outcomes are numerous and include improved oral and overall health, early detection of diet and nutrition problems, improved probability of successful treatment, improved wound healing and tissue resistance, and increased communication with patients. The extent to which practitioners provide oral health–related diet information in their practices or refer patients to a registered dietitian for medical nutrition therapy varies. Registered dietitians provide comprehensive nutrition care as a component of medical nutrition therapy. The American Dietetic Association (www.eatright.org) provides a nationwide nutrition network available at their Web site to locate a registered dietitian in a particular geographic area.

As the primary care provider for the oral cavity (the entry point to the gastrointestinal track), the dental professional should screen patients to

determine nutrition risk, integrate the finding into the patient's treatment plan, offer appropriate guidance to manage nutrition issues related to dental sequellae, and provide the necessary referrals.

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Appendix 1
Nutrition risk questions to ask patients about common symptoms

Weight
- Has your weight changed at all in the past 6 months?
  - If yes, how?
  - If weight loss, was it intentional?
  - If weight loss was intentional, what type of diet were you following for how long?
  - If weight gain, what are possible reasons you can attribute to weight gain?
- Do your clothes fit differently now than they did 6 months ago (1 clothing size = ~10 lb)?

Diabetes
- How do you manage your diabetes in terms of any special diet, medications, monitoring?
  - If insulin, what is the type, quantity, and dose schedule?
- *Do you follow any special diet?

Xerostomia
- *Do you have any difficulty chewing or swallowing?
  - If yes, to liquids (thin or thick), to solids, semisolids, or both?
- *Has this difficulty been progressive in degree of difficulty and types of foods?
- *Is swallowing painful?
  - If yes, when?
- *Can you eat a meal or snack without needing liquids?
  - If no, how many cups of liquids do you need to consume?
- *Have there been any changes in your medications or nutrient/herbal supplements?
  - If yes, describe changes.

Taste
- *Describe any changes in tastes that have occurred; what types of food, beverage? Has medication (prescription or over-the-counter) changed at all during this time?
- *Can you tell me, is your sense of taste different, missing, or does everything taste bad?
- *Do you have any difficulties chewing or swallowing food; if so, what?

Appendix (*continued*)

*Do you take any vitamin, mineral, herbal, or other nutritional supplements?
If yes, what, how much, what form, what frequency?
*Do you follow any special diet?

Activities of daily living

*Do you do your own food shopping and preparation? If no, what help do you have/need?
*Do you ever run out of money for food during the month?

Oral risk factors

*Do you have any difficulty biting, chewing, or swallowing foods or swallowing fluids?
If yes, detail what foods/fluids cause difficulty and how.
*How often during the day do you eat, including meals and snacks?
*How many times a day do you drink sweetened coffees, teas, soda, juices, or other sweetened beverages?
*When in the course of the day do you brush your teeth?

Questions to ask about osteoporosis risk

*How many servings of dairy products do you have on a typical day? 1 serving is equal to 1 oz of cheese or 1 cup of yogurt or milk
*Do you take a calcium supplement?
If yes, what is the name and how much do you take in 1 day?
Do you get any exercise in the course of a day or week? If yes, how many times a week do you exercise for at least 30 minutes?
If a woman, ask whether she is perimenopausal or postmenopausal.
Have you or a first-degree relative broken one or more bones?

*Note.* *denotes open-ended questions.