REVIEW ARTICLE

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Application of Diagnostic Laboratory Tests in the Field of Oral Medicine: A Narrative Review

Ji Woon Park[1,2], Yeong-Gwan Im[3,4]

[1]Department of Oral Medicine and Oral Diagnosis, School of Dentistry and Dental Research Institute, Seoul National University, [2]Department of Oral Medicine, Seoul National University Dental Hospital, Seoul, [3]Department of Oral Medicine, Dental Science Research Institute, School of Dentistry, Chonnam National University, [4]Department of Oral Medicine, Chonnam National University Dental Hospital, Gwangju, Korea

The purpose of laboratory tests in the field of oral medicine can be divided into two categories: (1) medical evaluation of patients with systemic diseases that are planning to receive dental care and (2) diagnosis of patients with certain oral diseases. First, laboratory tests are commonly used to evaluate patients with systemic diseases who need dental management. A combination of multiple tests is usually prescribed as a test panel to diagnose and assess a specific disease. Test panels closely related to oral medicine include those for rheumatoid arthritis, connective tissue disease/lupus, liver function, thyroid screening, anemia, and bleeding disorders. Second, laboratory tests are used as auxiliary diagnostic methods for certain oral diseases. They often provide crucial diagnostic information for infectious diseases caused by bacteria, fungi, and viruses that are associated with pathology in the oral and maxillofacial regions. Laboratory tests for infectious diseases are composed of growth-dependent methods, immunologic assays, and molecular biology. As the field develops, further application of laboratory tests, including synovial fluid analysis in temporomandibular joint disorders, salivary diagnostics, and hematologic biomarkers associated with temporomandibular disorders and orofacial pain conditions, is currently under scrutiny for their reliability as diagnostic tools.

Key Words: Clinical laboratory techniques; Diagnosis; Oral disease; Oral medicine

Introduction to Diagnostic Laboratory Medicine

Diagnostic laboratory medicine is the science of studying disease mechanisms and etiology, contributing to the screening and early detection of diseases, diagnosis, follow-up observation, treatment, and prognosis by examining certain biomarkers in vari-

Corresponding Author: **Yeong-Gwan Im**, https://orcid.org/0000-0003-2703-1475
Department of Oral Medicine, Dental Science Research Institute, School of Dentistry, Chonnam National University, 33, Yongbong-ro, Buk-gu, Gwangju 61186, Korea
TEL : +82-62-530-5578, FAX : +82-62-530-5679, E-mail : imygwise@jnu.ac.kr

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ous specimens collected from the human body. It is also a specialized medical field that provides clinical outcomes based on tests[1]. Diagnostic laboratory medicine is divided into specific areas: diagnostic hematology, transfusion medicine, clinical chemistry, diagnostic immunology, clinical microbiology, molecular genetics, cytogenetics, and laboratory informatics. Among them, diagnostic hematology, clinical chemistry, diagnostic immunology, and clinical microbiology have been extensively used in oral medicine.

In general, laboratory test results are presented with reference intervals with upper and lower limits. Reference values are established through values observed (measured) by reference individuals selected by clearly defined criteria. A reference interval is a reference limit of upper and lower bounds that includes the median 95% of the observed values obtained from reference persons[2]. The terms "normal value" and "normal range" are medically undesirable because they can be misleading. Instead, the terms "reference value" and "reference range" are recommended. The reference range refers to the test results of many healthy individuals exhibiting a normal pattern. A normal group is difficult to define and establish, whereas a "reference group" can clarify its properties and, according to medical judgment, distinguish it into several groups. The reference interval is determined by first establishing a reference group, testing these groups, and determining the reference range by obtaining the average value and standard deviation[1].

The application of diagnostic laboratory medicine in the area of oral medicine could be divided into two categories: (1) medical evaluation of patients with systemic diseases receiving dental management and (2) diagnosis of patients with oral diseases. Considering the expertise required as a dental specialist, furthermore, an oral medicine specialist, comprehensive knowledge of the application of appropriate diagnostic testing is crucial. Hence, this narrative review aims to provide an overview of the existing knowledge in this field of science. As a narrative review, this work did not follow a specific search strategy but summarized meaningful knowledge related to the subject.

Medical Evaluation of Patients with Systemic Diseases

Laboratory tests are used to obtain information on the morbidity and severity of the disease in patients who need dental care, those receiving medical management for previously diagnosed systemic

Table 1. Laboratory test panels closely related to oral medicine

Test panel	Test items included
Arthritis tests	ESR, CRP, uric acid, ANA, rheumatoid factor, ACPA, antiperinuclear factor
Connective tissue disease/lupus tests	ESR, CRP, urinalysis, CBC, C3, C4, ANA, anti-extractable nuclear antigens (ENA), anti-neutrophil cytoplasmic antibody (ANCA)
Liver function tests	Albumin, protein (total), bilirubin (total & direct), γ-GT, ALT, AST, ALP, LD, prothrombin time
Thyroid screening test	TSH, thyroxine (free T4), T3
Iron tests	Serum iron, TIBC, ferritin
Anemia tests	Serum iron, TIBC, ferritin, CBC with indices, reticulocyte count, peripheral blood smear microscopy, vitamin B12, folate, ESR, TSH
Bleeding disorder screening tests	PT, aPTT, platelet count, platelet function, thrombin time

ESR: erythrocyte sedimentation rate, CRP: C-reactive protein, ANA: anti-nuclear antibody, ACPA: anti-citrullinated protein antibody, CBC: complete blood count, γ-GT: gamma-glutamyltransferase, ALT: alanine transaminase, AST: aspartate transaminase, ALP: alkaline phosphatase, LD: L-lactate dehydrogenase, TSH: thyroid stimulating hormone, TIBC: total iron-binding capacity, PT: prothrombin time, aPTT: activated partial thromboplastin time.

diseases, and those who need to confirm unknown but suspected diseases. A combination of multiple test items is usually prescribed as a test panel to diagnose and evaluate a specific disease. The basic test panels closely related to oral medicine are presented in Table 1. Detailed information about the test items is described in the following subsections.

1. Sjögren's Syndrome

This condition is characterized by the oral symptoms of dry mouth. It is diagnosed based on the 2016 American College of Rheumatology (ACR)/European League Against Rheumatism (EULAR) diagnostic criteria[3]. The classification criteria are based on the weighted summation of the following five items. Anti-SSA/Ro positivity and focal lymphocytic sialadenitis (focus score ≥1 foci/4 mm^2), each score 3, abnormal ocular staining score ≥5 (or van Bijsterveld score ≥4), Schirmer's test result ≤5 mm/5 min, and unstimulated salivary flow rate ≤0.1 ml/min, each score 1. Individuals with signs and/or symptoms suggestive of Sjögren's syndrome with a total score of ≥4 for the above items meet the primary Sjögren's syndrome criteria. The specific items are described in Table 2.

2. Rheumatoid Arthritis

Rheumatoid arthritis (RA) is a chronic condition accompanied by joint damage in an irreversible form and profound disability due to pain and disfiguration. The prevalence is approximately 1% of the general population. The diagnosis is made when clinical symptoms are present, along with specific laboratory results. The laboratory tests that are applied include rheumatoid factor (RF) and anti-citrullinated protein antibody (ACPA). ACPA is known to be more specific compared to RF. Additionally, nonspecific inflammatory markers, including C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR), are also evaluated. According to the 2010 ACR/EULAR classification criteria, definite RA is based on the confirmed presence of synovitis in ≥1 joint, no possible alternative diagnosis that better explains symptoms, and reaching a total score ≥6 (out of a maximum of 10) from the scores of the following 4 domains which are the number and site of involved joints (score 0: 1 large joint; 1: 2~10 large joints; 2: 1~3 small joints (with or without large joint involvement); 3: 4~10 small joints (with or without large joint involvement); 5: more than 10 joints with at least 1 small joint), serologic abnormality (score 0: RF(–) and ACPA(–); 2: low RF(+) or low ACPA(+); 3: high RF(+) or high ACPA(+)), elevated acute-phase response (score 0: normal CRP and ESR; 1: abnormal CRP or ESR), and symptom duration (0: less than 6 weeks; 1: 6 weeks or more)[4].

3. Thyroid Disease

Thyroid diseases include a spectrum of thyroid-related conditions, including goiter, hyperthyroidism, hypothyroidism, and autoimmune thyroid diseases. Hypothyroidism incidence is 1%~2%, and the incidence increases with age and the female. The most common etiology of hyperthyroidism is Graves's

Table 2. The 2016 American College of Rheumatology/European League Against Rheumatism classification criteria for primary Sjögren's syndrome[3]

Item	Weight/score
Labial salivary gland with focal lymphocytic sialadenitis and focus score ≥1 foci/4 mm^2	3
Anti-SSA/Ro positive	3
Ocular Staining Score ≥5 (or van Bijsterveld score ≥4) in at least one eye	1
Schirmer's test ≤5 mm/5 min in at least one eye	1
Unstimulated whole saliva flow rate ≤0.1 ml/min	1

Modified from the article of Shiboski et al. (Arthritis Rheumatol. 2017; 69: 35-45)[3].

disease followed by toxic multinodular goiter as the second most common[5].

Thyroid function tests include laboratory tests such as calcitonin, thyroid-stimulating hormone (TSH), free thyroxine (T4), free triiodothyronine (T3), thyroglobulin (Tg), thyroglobulin antibodies, thyroid peroxidase antibodies (TPOAb), and TSH receptor antibodies (TRAb). TSH and free thyroid hormone tests are commonly used to investigate functional problems of the thyroid. Hashimoto's thyroiditis and Graves' disease are diagnosed by TPOAb and TRAb tests, respectively. Tg and calcitonin are considered important tumor markers applied in assessing differentiated thyroid carcinoma and medullary thyroid carcinoma, respectively.

A combination of low TSH in addition to increased free T4 and T3 levels indicates the possibility of primary hyperthyroidism, which is most frequently Graves' disease, multinodular goiter, or toxic nodule. Primary hypothyroidism patients will exhibit low free T4 or T3 and elevated TSH concentrations[6,7].

4. Anemia

Laboratory evaluations play a significant role in diagnosing anemia. This is more prominent, especially when physical examinations and history taking are not sufficient to reach a definitive diagnosis. However, the diagnosis of anemia is complex, and various hematologic biomarkers are utilized in the differential and final diagnosis of anemia to differentiate its cause.

Hematologic markers include hemoglobin (Hb), hematocrit, red blood cell count, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, red blood cell distribution width, reticulocyte count, white blood cell count, and platelet count. Biochemical testing includes transferrin, iron, iron-binding capacity (total iron-binding capacity and unsaturated iron-binding capacity), transferrin saturation, ferritin, zinc protoporphyrin, folate, vitamin B12, homocysteine, methylmalonic acid, and erythropoietin levels[8].

5. Diabetes Mellitus

Several tests are applied in the diagnosis of diabetes mellitus. The diagnostic criteria of the American Diabetes Association are described in Table 3[9]. According to the criteria, an A1C (also known as HbA1c) value should be ≥6.5%. The test must be based on a National Glycohemoglobin Standardization Program certified method that is standardized to the Diabetes Control and Complications Trial assay. Otherwise, fasting plasma glucose should be ≥126 mg/dl (7.0 mmol/L). Fasting is defined as no calorie intake for a minimum of 8 hours or 2-hour plasma glucose ≥200 mg/dl (11.1 mmol/L) with an oral glucose tolerance test. Testing should follow the guideline of the World Health Organization; hence the glucose load should contain the equivalent of 75 g of anhydrous glucose dissolved in water. A plasma glucose level of ≥200 mg/dl (11.1 mmol/L) could be used for

Table 3. Criteria for the diagnosis of diabetes mellitus[9]

A1C ≥6.5%. Method that is NGSP-certified and standardized to the DCCT assay.*
OR
FPG ≥126 mg/dl (7.0 mmol/L). No caloric intake ≥8 h.*
OR
2-hour plasma glucose ≥200 mg/dl (11.1 mmol/L) during an OGTT. The test should be performed as described by the WHO, using a glucose load containing the equivalent of 75 g of anhydrous glucose dissolved in water.*
OR
In a patient with classic symptoms of hyperglycemia or hyperglycemic crisis, a random plasma glucose ≥200 mg/dL (11.1 mmol/L).

NGSP: National Glycohemoglobin Standardization Program, DCCT: Diabetes Control and Complications Trial, FPG: fasting plasma glucose, OGTT: oral glucose tolerance test, WHO: World Health Organization.

*In the absence of unequivocal hyperglycemia, criteria 1~3 should be confirmed through repeat testing.

Modified from the article of American Diabetes Association (Diabetes Care. 2014; 37(Suppl 1): S81-90)[9].

diagnosis in a patient with classic symptoms of hyperglycemic crisis and/or hyperglycemia.

6. Liver Disease

There is a broad spectrum of liver diseases inducing hepatitis A, B, C, and cirrhosis. The prevalence of liver cirrhosis is increasing, and deaths attributed to cirrhosis increased from 1.5% to 2.4% in 2017[10].

Liver function tests are used to determine the presence or severity of liver diseases, to make specific diagnoses, and to follow the progression of the disease. Liver functions tests include total protein, albumin, alanine aminotransferase, alkaline phosphatase, aspartate aminotransferase, total bilirubin, and direct bilirubin levels[11]. The hepatitis panel is a battery of hematological tests that can identify present or past infection history by detecting antigens and/or antibodies in the blood. For hepatitis B, hepatitis B surface antigen and hepatitis B surface antigen-specific antibodies are analyzed[12]. In hepatitis C, the guidelines for diagnosis call for screening for hepatitis C virus (HCV) in adults (18 to 79 years old), pregnancy, and patients that have at-risk behavior. Anti-HCV antibody assessment with reflex HCV RNA polymerase chain reaction testing is recommended at the initial test stage[13].

7. Kidney Disease

Renal function testing generally includes blood urea nitrogen, serum creatinine, glomerular filtration rate (GFR), and creatinine clearance. According to a position statement from Kidney Disease Improving Global Outcomes[14], GFR ≥60 is considered normal; GFR <60 may indicate the possibility of kidney disease; and GFR ≤15 suggests the possibility of kidney failure, which requires dialysis or a transplant. Creatinine is a by-product of normal muscle breakdown and is removed through the kidneys. The level of creatinine is used to estimate GFR[15].

8. Dyslipidemia

Serum lipid levels are assessed by triglycerides, low-density lipoprotein cholesterol, and total cholesterol parameters[16]. The screening of blood lipids is recommended to assess the risk for coronary heart disease. However, there is still controversy regarding the timing to start screening. For those that are yet to be diagnosed with a specific disease, total serum cholesterol (TC) and high-density lipoprotein-cholesterol (HDL-C) screening are recommended. The National Cholesterol Education Program recommends that those over the age of 20 years get screened for TC and HDL-C every five years. For children, it is recommended when there is at least one parent TC ≥6.24 mmol/L. When specific criteria (TC ≥6.24 mmol/L; TC 5.20~6.23 mmol/L and HDL-C <0.91 mmol/L or two or more risk factors; TC <5.20 mmol/L but HDL-C <0.91 mmol/L) are met 12-hour fasting TC, HDL-C, triglyceride, and low-density lipoprotein-cholesterol (LDL-C) are recommended. Two to three separate analyses are required to confirm the LDL-C result before treatment. Tests should be done at 1~8 weeks intervals, and the average of the results should be evaluated[17].

Acquisition of Diagnostic Information on Oral Diseases

1. Oral and Maxillofacial Infections

Laboratory tests can obtain diagnostic information for assessing patients with oral diseases. Laboratory tests are beneficial for diagnosing various bacterial, fungi, and viral infections that cause diseases in the oral and maxillofacial regions (Table 4)[18]. Laboratory tests available for microbial infections are categorized into (1) growth-based methods, (2) immunodiagnostic tests, and (3) nucleic acid-based diagnostic tests (Table 5)[19]. Specific laboratory tests are selected from such diagnostic methods to identify causative microorganisms and aid the decision on the treatment strategy.

Table 4. Microbial infections of the oral and maxillofacial regions[18]

Category	Examples
Bacterial infections	Impetigo, erysipelas, streptococcal tonsillitis, and pharyngitis, scarlet fever, diphtheria, syphilis, gonorrhea, tuberculosis, leprosy, noma (necrotizing stomatitis), actinomycosis, and sinusitis
Fungal and protozoal infections	Candidiasis, histoplasmosis, blastomycosis, paracoccidioidomycosis, coccidioidomycosis, cryptococcosis, mucormycosis, aspergillosis, toxoplasmosis, and leishmaniasis
Viral infections	Acute herpetic gingivostomatitis, recurrent herpes simplex infection, varicella, herpes zoster, infectious mononucleosis, cytomegalovirus infection, measles, rubella, mumps, and acquired immunodeficiency syndrome

Table 5. Diagnostic microbiology and immunology for infectious diseases[19]

Category	Tests
Growth-dependent diagnostic methods	Growth on selective and differential media
	Miniaturized test kits
	Antimicrobial drug susceptibility testing
Immunology and diagnostic methods	Immunoassays for infectious disease
	Antibody titers
	Skin tests
	In vitro antigen-antibody reactions (serology)
	Neutralization
	Precipitation
	Agglutination
	Direct agglutination
	Passive agglutination
	Immunofluorescence (fluorescent antibodies)
	Enzyme immunoassay (EIA)
	Radioimmunoassay (RIA)
	Immunoblots
Nucleic acid-based diagnostic methods	Nucleic acid hybridization
	Nucleic acid amplification
	Polymerase chain reaction (PCR) testing
	Reverse transcriptase PCR (RT-PCR)
	Quantitative real-time PCR (qPCR)

The growth-based tests using culture is a method that can easily identify bacteria or fungi in a dental clinic without complicated equipment. Kim and Ahn[20] showed that a chromogenic agar medium could be a valuable tool for identifying and differentiating several important *Candida* species, such as *C. albicans*, *C. glabrata*, *C. tropicalis*, and *C. parapsilosis*, in patients with oral candidiasis diagnosed according to clinical findings and treated with antifungal agents.

Immunoassays provide an effective and simple means of identifying pathogens or exposure to pathogens. Immunoassay detects infectious agents by utilizing antibodies specific to the pathogen or pathogen products. For example, serologic tests on anti-varicella-zoster virus antibodies help identify unprotected individuals and distinguish primary infection from reactivation. The presence of IgG without IgM indicates previous exposure and immunity from reinfection, whereas the co-presence of the two antibodies suggests recent infection or vaccination[21]. Ahn et al.[22] reported a case in which syphilis was diagnosed using immunoassay in a patient with oral papular lesions suggestive of syphilis infection. The initial screening test, treponema pallidum antibody immunoassay, and the two confirmatory tests, such as venereal disease research laboratory test and treponema pallidum hemagglutination assay, indicated an active syphilitic infection. This case report demonstrated that laboratory tests are also valuable for diagnosing systemic diseases that cause lesions in the oral cavity.

2. Autoimmune Oral Mucosal Diseases

Autoimmune bullous diseases are a group of skin diseases caused by autoimmunity against intercellular adhesion molecules or basement membrane components of skin and mucosal surfaces. Examples of such diseases include pemphigus vulgaris, paraneoplastic pemphigus, bullous pemphigoid, and mucous membrane pemphigoid. Autoantibodies

are directed against various molecular components of epithelial cells and underlying connective tissue, including desmosomes or basement membranes[18].

In autoimmune bullous diseases, tests for differential diagnosis are necessary because the clinical features of oral lesions may overlap. Immunofluorescence microscopy is essential for discriminating between autoimmune and non-autoimmune bullous diseases. Direct immunofluorescence differentiates between pemphigus and pemphigoid diseases, and additional serological tests are required to diagnose paraneoplastic pemphigus. Biochemical tests, including enzyme-linked immunosorbent assay (ELISA), immunoblotting, and immunoprecipitation, help diagnose autoimmune bullous diseases. ELISA and immunoblot are commonly used to specify targeted antigens[23].

Direct immunofluorescence combined with serological testing for circulating autoantibodies is recommended for diagnosing mucosal pemphigoid. Direct immunofluorescence microscopy detects tissue-associated IgG, IgA, and complement C3. In most patients, serum autoantibodies are present in low levels and variable proportions, depending on the involved sites. Circulating autoantibodies are determined by indirect immunofluorescence tests using tissue substrates, ELISA with different recombinant forms of the target antigens, or immunoblot using other substrates. The primary target antigen in mucous membrane pemphigoid is collagen type XVII (BP180)[24], and the NC16A ELISA is frequently used to detect circulating autoantibodies[25]. Hayakawa et al.[26] reported that they could differentiate subtypes of mucous membrane pemphigoid, such as the anti-BP180-type, the anti-laminin-332-type, and the combined type using a combination of indirect immunofluorescence, immunoblot, and ELISA.

3. Burning Mouth Syndrome

Burning mouth syndrome (BMS) is a burning or dysesthetic sensation in the mouth that occurs for more than 2 hours a day for more than three months without apparent causative lesions on clinical examination and investigation[27]. Since the symptom expressed as a burning sensation in the mouth may be a secondary phenomenon due to local or systemic factors, BMS is diagnosed when all such causes have been ruled out.

Laboratory tests are used to identify local or systemic conditions that can cause a burning sensation in the mouth. A complete blood count indicates a variety of body conditions, including infection and anemia. Blood levels of iron, zinc, folic acid, thiamine, riboflavin, pyridoxine, and vitamin B12 can be considered to determine a patient's nutritional status. Blood glucose level needs to be checked to rule out diabetes, which can cause neuropathic pain. Since candida infection of the oral mucosa can cause a burning sensation in the oral cavity, a culture test for the fungus should be performed if suspected[28]. Morr Verenzuela et al.[29] retrospectively reviewed the screening blood test results of 659 patients with BMS and suggested that screening items, including fasting blood glucose, vitamin D, pyridoxine, zinc, thiamine, and TSH were reasonable. However, they also reported that checking blood levels of vitamin B12 and folic acid was not essential because vitamin B12 and folic acid deficiencies were rare in patients with BMS.

Further Applications in Oral Medicine

1. Synovial Fluid Analysis of the Temporomandibular Joint Disorder

In pathologic conditions, certain changes may occur in the synovial fluid of the temporomandibular joint (TMJ). This may be useful in diagnosing joint conditions when the change may be quantified and analyzed regarding the severity and characteristics of the disease[30].

Kaneyama et al.[31] compared the levels of various cytokines in the synovial fluid from 55 patients with

temporomandibular disorders (TMD) patients and five asymptomatic healthy volunteers. The concentrations of tumor necrosis factor-α, interleukin (IL)-6, IL-1β, and soluble tumor necrosis factor receptors I and II were significantly higher in the synovial fluid of the patients. Other studies have reported levels of inflammatory cytokines and chemokines of TMJ synovial fluid; however, the results are inconsistent and do not show high levels of correlation with clinical symptom severity. Further research based on well-defined patient groups is necessary, and strict control of numerous factors that may affect the concentration of such mediators is required.

2. Salivary Diagnostics

The diagnostic value of saliva highly depends on its reproducibility. Also, the correlation between blood and saliva levels should be reasonably high. Nam et al.[32] investigated the reliability of inflammatory and oxidative stress salivary markers. Unstimulated whole saliva (on the first visit and after 2~3 days) and blood samples (on the first visit) were collected from 37 healthy young males. Nam et al.[32] found IL-6 was the only marker that showed a significant correlation between both. Such results indicate the need to locate specific markers in which saliva could act as a plasma substitute. Considering the many advantages of saliva over plasma, such as noninvasiveness, ease of collection, and abundance, the role of saliva in diagnosing systemic disease is likely to increase with the development of technology.

Kim et al.[33] investigated salivary markers related to BMS. The saliva samples of female patients with BMS were collected, and levels of cortisol, 17β-estradiol, progesterone, dehydroepiandrosterone (DHEA), and enzymatic activity of α-amylase were analyzed. Levels of 17β-estradiol, progesterone, and DHEA were significantly correlated with age. The patient group had significantly higher levels of cortisol and 17β-estradiol. The older group (≥60 years) showed a significantly lower level of progesterone. Such results stress the need to consider age in interpreting test results based on salivary samples.

3. Hematologic Biomarkers Associated with Temporomandibular Disorders/Orofacial Pain Conditions

Kim et al.[34] evaluated differences in clinical symptoms of TMD patients according to antinuclear antibody (ANA)/RF positivity. Clinical examinations were done following the Research Diagnostic Criteria for TMD in 257 patients. The results suggested the possibility of autoimmunity and inflammation playing a role in the pathologic mechanism of TMD pain and related dysfunction, and male TMD patients with ANA/RF positivity showed less range of motion of the TMJ and worse treatment response.

The levels of cytokines, chemokines, autoantibodies, and non-specific inflammatory markers and their levels according to pain severity and duration were assessed in 66 female TMD patients in their 20s. IL-2, -8, -13, IFN-γ, regulated upon activation normal t-cell expressed and secreted (RANTES), prostaglandin E2, and thrombopoietin levels showed a significant effect on indices reflecting jaw function, generalized pain intensity, and health-related quality of life[35].

When 357 TMD patients were divided into groups according to the primary source of pain (muscle, joint, and combined pain) and according to the Graded Chronic Pain Scale (GCPS), the CRP level was significantly higher in the joint pain group compared to the combined pain group. There were significant correlations between specific TMD clinical and psychological indices and hematologic indices[36].

4. Application to Oral Medicine Research

The use of laboratory tests could be considered in diagnosing halitosis patients. When hematologic markers and halitosis measurement were investigated in 125 patients, the white blood cell count was significantly higher in the genuine halitosis group. The duration of halitosis was highly associated with ESR

values, and neutrophil to lymphocyte ratio values, a non-specific marker of systemic inflammation, were significantly related to genuine halitosis diagnosis[37].

Microbiome samples are a trending issue in diagnostic science since the importance of gut microbiomes has been revealed through numerous clinical and preclinical studies. When the microbiome of unstimulated saliva samples from 19 primary BMS patients and 22 healthy adults were sequenced of the V3-V4 region of the 16S rRNA gene, there was a clear difference in the microbial composition between the groups at all taxonomic levels. Alpha diversity indexes were significantly lower in the BMS group. *Streptococcus*, *Rothia*, *Bergeyella*, and *Granulicatella* genera were dominant in the BMS group. On the other hand, *Prevotella*, *Hemophilus*, *Fusobacterium*, *Campylobacter*, and *Allorevotella* genus were more abundant in the healthy group[38].

Conclusion

Various types of laboratory tests provide helpful information for evaluating and diagnosing dental patients with systemic diseases and conditions and also for further investigation of those with oral diseases. Oral medicine specialists should be able to select and apply appropriate laboratory tests among the wide range of currently available tests and choose the necessary items to reach a specific diagnosis. At the same time, trained specialists should be able to interpret the meaning of the test results accurately.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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