Research paper

Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 17, Issue, 05, pp.704-711, May 2026

International Journal of Recent Scientific Research

ISSN: 0976-3031

Subject Area : Health Science

IMMUNOMODULATORS AND THEIR ROLE IN ORAL DISEASES- A REVIEW

Dr. Sumalatha M N [1], Dr. Gadiputi Sreedhar[2] and Jayavardhini P [3].

1Professor, Department of Oral Medicine and Radiology, C.K.S Theja Institute of Dental Sciences and Research, Tirupathi, Andhra Pradesh, India

[2]Professor and Head, Department of Oral and Maxillofacial Pathology and Microbiology, C.K.S Theja Institute of Dental Sciences and Research, Tirupathi, Andhra Pradesh, India

[3]Reader, Department of Oral and Maxillofacial Pathology and Microbiology, C.K.S Theja Institute of Dental Sciences and Research, Tirupathi, Andhra Pradesh, India

DOI: http://dx.doi.org/10.24327/ijrsr.20261705.0130

ARTICLE INFO

Article History:

Received 16th April 2026
Received in revised form 25th April 2026
Accepted 19th May 2026
Published online 28th May 2026

Key words:

Immunomodulators, autoimmune diseases, cancers.

ABSTRACT

Immunomodulators are a diverse group of agents that modify the immune system's activity to achieve therapeutic benefits. They can either enhance immune responses [immunostimulants] or suppress those [immunosuppressant's] depending on the clinical need. These drugs play a critical role in autoimmune diseases, chronic inflammatory conditions, cancers and organ transplantation. The use of immunomodulators requires careful monitoring due to the risk of adverse effects like increased susceptibility to infections or immune imbalance. Immunomodulators acts through various mechanisms like regulating cytokine production, altering lymphocyte proliferation and differentiation, modulating signaling pathways involved in immune activation.

INTRODUCTION

Immunomodulators are becoming very popular in the worldwide natural health industry as people start to realize the importance of a healthy immune system in the maintenance of health and the prevention and recovery of disease. An immunomodulator is any substance that helps to regulate the immune system. This "regulation" is a normalization process, so that an immunomodulator helps to optimize immune response. The immunomodulators do not tend to boost immunity, But to normalize it the immunomodulators how they work in the body is still largely a mystery[1].

Certain drugs are used to suppress the immunity are called immunosuppressant. These drugs can be useful in autoimmune diseases and useful for preventing the rejection of organ transplants[2].

Immunomodulation is any procedure, which can alter the immune system of an organism by interfering with its function. Modulation of immune system may result in suppression or stimulation of immunological reactivity. Immunological agents, which produce active or passive immunity, are used to prevent or to modify certain infectious diseases such as small pox, cholera and poliomyelitis[1].

*Corresponding author: **Dr. Gadiputi Sreedhar**

Prof & HOD, Vice Principal, Dean Academics, Department of Oral Pathology and Microbiology

Classification of immunomodulators [3];

Immunosuppressive agents:-

1. Specific T cell inhibitors;
   - Cyclosporine
   - Tacrolimus [Fk506]
2. Glucocorticoids;
   - Prednisone
   - Prednisolone
   - Dexamethasone
   - Hydrocortisone.
3. Cytotoxic drugs; Azathioprine
   - Mycophenolate Mofetil
   - Cyclophosphamide
   - Others; Methotrexate
   - Chlorambucil
   - Vincristine

Vinblastine and

Dactinomycin.

4. Antibody reagents;

Antithymocyte globulin

Muromonab-CD3 monoclonal antibody

Rh_0 [D] immune globulin

5. Miscellaneous immunosuppressive agents.

Methoxsalen

Thalidomide

B. Immunomodulating agents

a. Natural adjuvants; Bacillus calmette-guerin Immuno globulin

b. Synthetic agents; Levamisole, Isoprinosine, Cimetidine

c. Cytokines; Interferon's

C. **Immunomodulators of plant origin.**

1. Cyclosporine

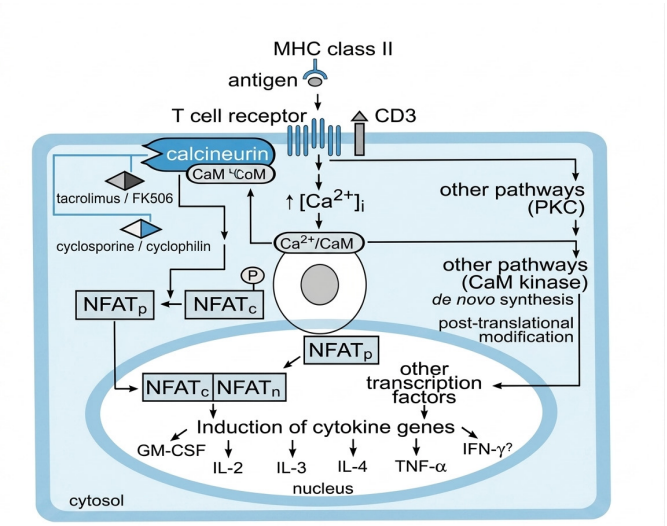
Cyclosporine is a, cyclic undecapeptide is metabolized to more than 30 metabolites. Cyclosporine is synthesized by the fungus Tolypocladium inflatum gams. These cyclosporines are synthesized by cyclosporine synthetase, a 800 kDa multifocal enzyme[2].

Mechanism of action[3]

Cyclosporine has a very selective inhibitory effect on T lymphocytes, suppressing the early cellular response to antigenic and regulatory stimuli.

Cyclosporine readily diffuses into the cytoplasm of target cells. Among the pathways they inhibit T cell receptor activated signal transduction pathway. Activation of the T cell receptor causes, an increase in intracellular Ca+, which activates a Ca+ dependent, serine or threonine phosphatase, known as calcineurin. One substrate of calcineurin, a cytosolic component of NFAT (NFATc; nuclear factor of activated T cells) moves from the cytoplasm to the nucleus upon dephosphorylation. By associating with other nuclear components of NFAT, this calcineurin substrate regulates the transcription of many genes, including the genes encoding interleukin-2, granulocyte macrophage colony- stimulating factor (GM-CSF), tumor necrosis factor α (TNF-α), interferon α and other interleukins. Cyclosporine in association with its binding protein, cyclophilin, and tacrolimus in association with its binding protein, FKBP, stably associate with calcineurin at the endothelial surface of T cells and inhibit calcineurin catalytic activity. [Fig: 1]

T- cell activation leads to enhanced transcription of a number of T-cell genes coding for specific cytokines, particularly interleukin-2,IL-3,IL-4,TNF-α, Interferon-¥. Increased expression of TGF-ß may contribute to the overall immunosuppressive effect produced by cyclosporine [Suthanthiran and strom,1994;wiederrecht et, al 1993].



Pharmacokinetics[4]

a. Cyclosporine can be administered either intravenously or orally. Intravenously 50 mg\ml solution made up in an ethanol-polyoxylated castor oil mixture.

b. Orally 25 mg or 100 mg as a soft gelatin capsule [sand immune] or as a newer oral micro emulsion formulation [sand immune neural].

c. The cyclosporine administered in the original soft gelatin capsule formulation is absorbed slowly and incompletely with bioavailability ranging from 20% to 50%.

d. The micro emulsion formulation was developed to improve the absorption characteristics of cyclosporine and was approved for clinical use in the United States in 1995.

e. Ingestion of fatty meal significantly delays absorption of cyclosporine in the gelatin capsule formulation but not in micro emulsion form.

Therapeutic considerations in oral diseases[5]

A. Cyclosporine can be used either systemically or topically in the treatment of lichen planus. Systemic dose of cyclosporine is 8mg\kg\day for 8 weeks. Cyclosporine rinse is also available for oral lesions; 5ml rinse TID, for 8weeks.

B. It has been used systemically in autoimmune diseases like Bullous pemphigoid and pemphigus. The dose for these diseases is 7.5 to 25 mg\kg\day for duration of 6 weeks.

C. Cyclosporine has proved effective in the treatment of bechet's syndrome, apthous stomatitis (0.5 to1mg\kg\ day), and uveitis.

Adverse effects[1]

Renal toxicity, Nephrotoxicity, Hypertension, hepatotoxicity, neurotoxicity, hirsutism,

Gingival hyperplasia and gastrointestinal and abdominal pain][6].

2. Tacrolimus

Chemistry; Tacrolimus is a macrolide antibiotic that was extracted from a fermentation broth of the soil microorganisms streptomycin tsukubaensis. The name, tacrolimus, derives from T for Tsukuba, Japan, it is a macrolide, hence the letters

ACROL, and the letters IMUS represent its potential for immunosuppression[7].

Mechanism of action; Similar to cyclosporine [fig 1]

Pharmacokinetics[7]

a. Tacrolimus is highly lipophilic, with good solubility in methanol, chloroform, acetone, and propylene glycol.

b. Tacrolimus can be administered intravenously or orally. After short intravenous infusion of 2-4 hours, tacrolimus peak concentrations initially decline rapidly, indicating a rapid distribution phase of the drug. The intravenous dose for adults is 25 to 50 µg per kg per day and for pediatric patients is 50 to 100 µg\kg per day.

c. Following oral administration, tacrolimus is poorly, erratically, and incompletely absorbed. The time for peak concentration after oral administered varies from 1-4 hours. The oral dose range for adults is 150 to 200µg\kg per day, and for pediatric patients is 200-300µg\kg per day.

Therapeutic considerations in oral disease[5]

A. Topical application of tacrolimus 0.1% for 3 to 4times per day is used in the management of symptomatic lichen planus.

B. It is used as an adjuvant therapy with other immunosuppressive drugs in the management of pemphigus vulgaris, bullous pemphigoid.

Adverse effects

Nephrotoxicity, neurotoxicity [headache, tremor, insomnia, pain], gastro intestinal toxicity [diarrhea, nausea],

Cardiovascular toxicity [hypertension] and metabolic toxicity [hyperkalemia, hypomagnesaemia, hyperglycemia] [7].

3.Glucocorticoids

Glucocorticoids continue to be used either alone or in combination with other immunosuppressive agents for preventing transplant rejection and for treating autoimmune disorders.

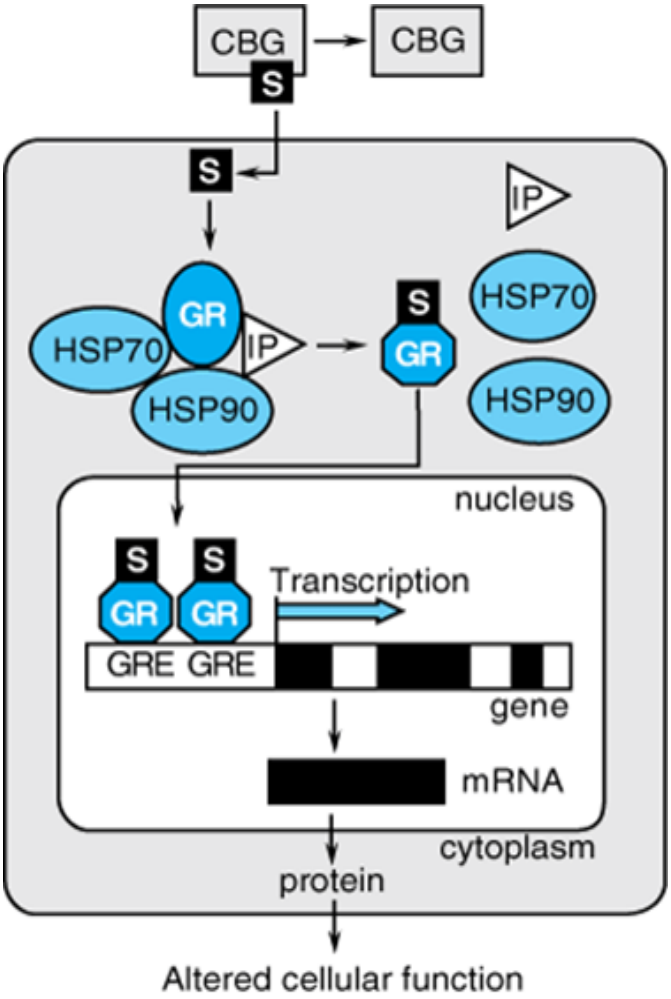
The most common glucocorticoids used for these indications are prednisone (ELTASONE, others) and prednisolone (HYDELTRASOL, others)[1].

Mechanism of action

Glucocorticoid receptor (GR) resides predominantly in the cytoplasm in an inactive form until it binds the glucocorticoid steroid ligand denoted as S in the figure, 59-5 given below.

Steroid binding results in receptor activation and translocation to the nucleus. The inactive GR is found as a complex with other proteins, including heat shock protein (HSP) 90 and HSP70 and a56kDa immunophilin (IP), one of the groups of intercellular protein, which binds the immunosuppressive agents.[fig 2]

Regulation of gene expression by glucocorticoids; following ligand binding, HSP90 and several others of the associated proteins dissociate, and the GR is directed into the nucleus where it can interact with specific DNA sequences within the regulatory regions of affected genes.



These short DNA sequences that are recognized by the activated glucocorticoid receptor are termed glucocorticoid-responsive elements (GREs) and provide specificity to the induction of gene transcription by glucocorticoids. So glucocorticoids inhibit T cell proliferation, T cell dependent immunity, and the expression of genes encoding cytokines (IL-1, IL-2, IL-6, interferon α and TNF-α)[1].

Pharmacokinetics

1. Absorption; Glucocorticoids are frequently prescribed because of their immunosuppressive and anti-inflammatory properties. They are administered locally, through topical and intra lesional routes, and systemically, through intramuscular, intravenous and oral routes.

Therapeutic considerations in oral diseases[5]

A. Glucocorticoids used as first line of treatment in oral lichen planus either via topical or systemic administration depending on the severity of the lesion. Topical preparation of triamcinolone acetonide 0.1% cream or ointment is most commonly used. The most commonly prescribed systemic steroid for OLP is prednisone 40 to 80 mg once daily for more than 10 days.

B. B .Glucocorticoids also used in the management of oral sub mucous fibrosis. Kakar P K, 1985 recommended a course of local injection of hyaluronidase bi-weekly for first 3 weeks followed by a combination of dexamethasone 4 mg & hyaluronidase 1500 IU for next 7 weeks for maximal improvements. With this treatment

increased vascularity to the affected site is observed, which is attributed to fibrinolytic, anti-allergic and anti-inflammatory action of glucocorticoid.

C. Topical corticosteroid preparation-triamcinolone acetonide 0.1% for 3 to4 time's daily application is used in the management of apthous stomatitis.

D. Prednisolone in a dose of 30mg\day for several days used in the management of moderate to severe cases of erythema multiforme.]

E. Topical or systemic prednisone is also used in the management of pemphigus, bullous pemphigoid and benign mucous membrane pemphigoid. The dose required for these conditions is 5 to 60mg per day in divided doses.

4. Cytotoxic drugs

Many of the cytotoxic drugs used in cancer chemotherapy have been absorbed to produce immunosuppression, leading to investigation of the usefulness of these compounds as immunosuppressive agents in the prevention of transplant rejection and the treatment of autoimmune disorders[1].

These drugs are thought to have a common mechanism of action as immunosuppressive agents in that they prevent the clonal expression of both B and T lymphocytes.

Eg; Azathioprine, Mycophenolate mofetil, Cyclophosphamide, Methotrexate, Chlorambucil, Vincristine, Vinblastine and Dactinomycin[1].

A. **Azathioprine**

Chemistry; Azathioprine is a purine antimetabolite. It is a pro drug of 6- metacaptopurine containing an imidazole group attached to the sulfur atom at the 6-position of the purine ring[1].

Mechanism of action

Azathioprine is a purine analog that is quickly metabolized in vivo to 6-mercaptopurine (6-MP), and thereafter to 6-thioguanine nucleotide (6-TNG). These compounds act as purine antagonists that interfere with synthesis of DNA, RNA, and protein. They are known to act as immunomodulators, due to their selective effects on T cells and T cell dependent responses and their effects on natural killer cell activity and hum oral responsiveness[8].

pharmacokinetics

Azathioprine (IMURAN) is available both for oral and intravenous administration. Oral administration is the preferred route in most cases, since intravenous preparation is an extreme irritant. The dose depends on the clinical requirements and the hematological tolerance of the patient, but is usually in the range of 1`-4 mg\kg\day[8].

Therapeutic considerations in oral diseases[5]

A. Systemic Azathioprine is used as a steroid sparing immunosuppressant in the management of chronic oral vesiculoerosive diseases, such as pemphigus vulgaris and lichen planus. The dose of Azathioprine is 2-2.5mg\kg\day.

B. It also used in the management of systemic lupus erythematous in a dose of 2 to 3mg per kg per day.

Side effects

The side effects of systemic therapy with Azathioprine can be categorized as either allergic or non-allergic in nature.

a. The allergic type reactions are dose independent and may include rash, fever, pancreatitis, arthralgia's, malaise, nausea and diarrhea.

B. Non allergic reactions are dose dependent and include leucopenia, thrombocytopenia, hepatitis, and infection.

C .Azathioprine is also thought to be a mutagen and carcinogen[8].

B. **Cyclophosphamide;**

Chemistry; cyclophosphamide belongs to the nitrogen mustard subclass of alkylating agents[1].

Mechanism of action

Cyclophosphamide alkylates DNA, particularly in proliferating cells, thereby interfering with DNA synthesis and function.

Both T and B cells are affected by cyclophosphamide, although the toxicity produced is greater in B cells since their rate of recovery is slower. Consequently, this drug has its greatest effect through suppressing hum oral immunity[1].

Pharmacokinetics

Cyclophosphamide is well absorbed orally. This drug is mainly activated by the cytochrome P450 system. The cyclophosphamide first converted to 4- hydroxyl cyclophosphamide, which is in a steady state with the acyclic tetramer, aldophosphamide.

In tumor cells, the aldophosphamide may cleave spontaneously, generating stoichiometric amounts of phosphor amide mustard and acrolein.

The phosphor amide is responsible for anti tumor effects and the acrolein responsible for the hemorrhagic cystitis seen during therapy with cyclophosphamide [9].

Therapeutic uses

Cyclophosphamide [CYTOXAN] is usually administered orally or intravenously. Recommended doses vary widely.

As a single agent, a daily dose of 100 mg per m^2 orally for 14 days has been recommended for patients with more susceptible neoplasms such as lymphomas and chronic leukemia's[1].

A higher dose of 500 mg per m^2 intravenously in combination with other drugs is often employed in the treatment of carcinomas and lymphomas[1].

The leukocyte count generally serves as a guide to dosage adjustments in prolonged therapy. A total leukocyte count between 2500 and 4000 cells per cubic millimeter is recommended as the target for dose adjustment[1].

C. **Methotrexate**

It's a foliate antagonist.

It is a potent immunosuppressant which markedly depresses cytokine production and cellular immunity, and has anti-inflammatory property[9].

Mechanism of action

It is one of the oldest and highly efficacious anti neoplastic drugs; inhibits dihydrofolate reductase [DHFRase]- blocking

the conversion of dihydrofolic acid (DHFA) to tetra hydrofolic acid (THFA) which is an essential coenzyme required for one carbon transfer reactions in de novo purine synthesis and amino acid interconversions. The inhibition is pseudo irreversible because methotrexate has 50,000 times higher affinity for the enzyme than the normal substrate.

Methotrexate has cell cycle specific action- kills cells in S phase; primarily inhibits DNA synthesis, but also affects RNA and protein synthesis[1].

Pharmacokinetics

Methotrexate is absorbed orally, 50% is plasma bound, little metabolized and largely excreted unchanged in urine.

Distribution of methotrexate into the body spaces, such as pleural cavity or peritoneal cavity, occurs slowly. Metabolism of methotrexate in human beings is usually minimal.

After high doses, however, metabolites do accumulate; these include 7- hydroxyl-methotrexate, which is potentially nephrotoixc[9].

Therapeutic consideration in oral diseases

It has been used as a first line of drug in many autoimmune diseases like rapidly progressing rheumatoid arthritis (7.5mg weekly), pemphigus, myasthenia gravis, and chronic active hepatitis[5].

Antibody reagents

1. Antithymocyte globulin;.

Antithymocyte globulin [ATGAM] is a purified immunoglobulin prepared commercially from hyper immune serum of horse, rabbit, sheep, or goat following immunization with human thymic lymphocytes. The anti thymocyte globulin binds to the surface of T lymphocytes that are found in the circulation, resulting in lymphopenia and impaired T –cell immune responses[10].

Drug deposition and pharmacokinetics

Antithymocyte globulin is available as a solution for intravenous injection. It usually is administered through a large or central vein at a daily dose of 10 to 30 mg per kg in saline over several hours. The half-life of this immunoglobulin is between 3 and 9 days[10].

Therapeutic uses

Antithymocyte globulin is used primarily today to treat allograft rejection during acute rejection episodes. This includes use in kidney and heart as well as other types of solid organ transplantation.

It also has been used also prophylactic ally to prevent rejection[10].

Mechanism of action; similar to cyclosporine

Therapeutic uses

Muromonab CD3 [ORTHOCLONE OKT3] has been used primarily to prevent acute rejection of kidney, liver, and heart transplants [Waid et al 1992; Norman et al 1993]

This antibody has been used to deplete T cells from donor bone marrow prior to bone marrow transplantation[1].

Immunomodulators are divides into;

a. Natural agents

b. Synthetic agents

c. Cytokines.

Natural agents includes; Bacillus calmette- Guerin [BCG], immunoglobulin

Synthetic agents includes; Levamisole, Isoprinosine and cimetidine.

1.Bacillus calmette- Guerin

Bacillus Calmette- Guerin [BCG] and its active component, muramyl dipeptide, are bacterial products that have been shown to produce an immuno stimulant effect. BCG is a viable strain of mycobacterium bovis that has been used for immunization against tuberculosis[1].

Therapeutic uses

BCG has its primary effect on the T- cell. It is believed that it also can stimulate natural killer cells. Although BCG has been used with many different neoplasm's, its major effect has been with bladder cancer, where it has been shown to be effective when used as an intra-vesicular agent [Freiberg, 1993][1].

2.Immunoglobulin[18]

Is a sterile serum protein solution (15 to 18%) containing antibodies from human blood, which is derived from pooled human serum; it consists primarily of IgG (95%) and small amounts of other IgS [IgM and IgA] and other serum proteins.

The gamma globulin obtained from pooled, human, adult blood is known as immune serum[10].

Clinical uses

a. Hypogammaglobulinemia.

b. Mumps and rubella prophylaxis.

c. Mumps and poliomyelitis

d. Diphtheria

e. In preventing secondary infection in susceptible individuals e.g.; after burns.

Synthetic agents

1. Levamisole

Is an anti-helminthic drug that possesses nonspecific immune stimulatory properties.

Mechanism of action

Levamisole is a heterocyclic compound that is an effective anti-helminthic agent and is also immunoregulatory. Its immune-regulatory mode of action is similar to thymic hormone thymopoietin. Chemically, levamisole may form a thymopoietin mimetic tertiary structure; stimulate lymphocytes by its imidazole component. It acts mainly by enhancement of suppressor T cell function that normally prevents autoimmune response[11].

Therapeutic considerations of levamisole[9]

a. Levamisole [ERGAMISOL] has been used in Hodgkin's

disease, rheumatoid arthritis and more recently in adjuvant chemotherapy of colorectal cancer [Chirigos, in 1992; Kurman, 1993].

b. It also been used successfully in the management of recurrent apthous stomatitis and herpes labialis.

c. It also used in the management of oral sub mucous fibrosis, 150mg\day thrice in a week for 6 weeks.

Cytokines

[Interferon's, Colony stimulating factors & Interleukins]

Cytokines are large heterogeneous group of proteins with diverse functions. Cytokines mediate their effects via cell surface receptors on or in relevant target cells and the action is similar to hormones. The first group of cytokines discovered, the interferon's, were followed by colony stimulating factors and interleukins. Colony stimulating factors regulate the proliferation and differentiation of bone marrow progenitor cells[2].

Cytokines produced by lymphocytes are celled as lymphokines, whereas cytokines produced by monocytes or macrophages are celled as monokines.

Table 1. There are different varieties of cytokines listed in the table[1].[Bertram katzung, 8th edition]

Cytokine	Properties
Interferon-α (IFN-α)	Antiviral, oncostatic, activates NK cells
Interferon-β (IFN-β)	Antiviral, oncostatic, activates NK cells
Interferon-γ (IFN-γ)	Antiviral, oncostatic, secreted by and activates or upregulates T_H1 cells, NK cells, CTLs, and macrophages
Interleukin-1 (IL-1)	T cell activation, B cell proliferation and differentiation, HCF[1]
Interleukin-2 (IL-2)	T cell proliferation, T_H1, NK, and LAK cell activation
Interleukin-3 (IL-3)	Hematopoietic precursor proliferation and differentiation
Interleukin-4 (IL-4)	T_H2 and CTL activation, B cell proliferation
Interleukin-5 (IL-5)	Eosinophil proliferation, B cell proliferation and differentiation
Interleukin-6 (IL-6)	HCF, T_H2, CTL, and B cell proliferation
Interleukin-7 (IL-7)	CTL, NK, LAK, and B cell proliferation, thymic precursor stimulation
Interleukin-8 (IL-8)	Neutrophil chemotaxis, proinflammatory
Interleukin-9 (IL-9)	T cell proliferation
Interleukin-10 (IL-10)	T_H2 suppression, CTL activation, B cell proliferation
Interleukin-11 (IL-11)	Megakaryocyte proliferation, B cell differentiation
Interleukin-12 (IL-12)	T_H1 and CTL proliferation and activation
Interleukin-13 (IL-13)	Macrophage function modulation, B cell proliferation
Interleukin-14 (IL-14)	B cell proliferation and differentiation
Interleukin-15 (IL-15)	T_H1, CTL, and NK/LAK activation
Interleukin-16 (IL-16)	T lymphocyte chemotaxis, suppresses HIV replication
Interleukin-17 (IL-17)	Stromal cell cytokine production
Tumor necrosis factor-α (TNF-α)	Oncostatic, macrophage activation, proinflammatory
Tumor necrosis factor-β (TNF-β)	Oncostatic, proinflammatory, chemotactic
Granulocyte colony-stimulating factor (G-CSF)	Granulocyte production
Granulocyte-macrophage colony-stimulating factor (GM-CSF)	Granulocyte, monocyte, eosinophil production
Macrophage colony-stimulating factor (M-CSF)	Monocyte production, macrophage activation
Erythropoietin (epoetin, EPO)	Red cell production
Thrombopoietin (TPO)	Platelet production
1Hematopoietic cofactor (HCF): Plays some role, but not the central role, in growth and differentiation of bone marrow-derived cells.	

a. Interferons

Interferons are a family of proteins and glycoprotein's that have a variety of biologic actions in minute amounts. Interferons were discovered in 1957 at who had been working on viral interference. They conducted an unconventional experiment with egg membranes and live viruses they observed that a live virus had failed to grow; something has interfered the process. Thus the name interferon[12].

Table 2

Cytokine	Size KDa	Primary cell origin	Target cell	Primary effects on target cell
IFN α \ß	18	Macrophage (α) Fibroblast (ß)	All cells	Antiviral anti pro-liferative

INF ¥	35-70	T cells of CD4+ and CD8+ lineage	Cytotoxic T cells Mac-rophages	Antiviral Immune

Therapeutic considerations in oral diseases

a. Interferon gamma; this plays a role in the treatment of patients with OSF because of its immuno regulatory effect. IFN-gamma is a known anti-fibrotic cytokine. Patients treated with an intra lesional injection of IFN-gamma experienced improvement of symptoms. IFN-gamma, through its effect of altering collagen synthesis, appears to be a key factor to the treatment of patients with OSF, and intra lesional injections of the cytokine may have a significant therapeutic effect on OSF[12].

B. Interleukins

There are more than 17 different varieties of interleukins but out of them only interleukin-2 plays a very important role in immuno modulation.

Interleukin-2 currently available as a recombinant protein. Originally this cytokine was called T cell growth factor because its ability to stimulate the production of T helper and T cytotoxic cells[1].

Mechanism of action

IL-2 binds to IL-2 receptors on the surface of responsive cells, inducing proliferation and differentiation of T helper cells and T cytotoxic cells. IL-2 also has been demonstrated to induce B-cell proliferation, stimulate macrophage activity, and increase the toxicity of natural killer cells[1].

Therapeutic uses

IL-2 has been administered as an intravenous bolus, by continuous intravenous infusion, subcutaneously, and intramuscularly.

Anti-tumor activity of IL-2 has been demonstrated most consistently with metastatic melanoma and with renal cell carcinoma[1].

C. Colony stimulating factors

Granulocyte \ macrophage colony stimulating factor

Sargramostim is a commercially available GM-CSF. Human GM-CSF was initially purified from a T cell leukemia infected lymphoblastic cell line and cloned in 1985. The in vitro effects of GM-CSF is more potent than those of G-CSF, as the agent is active earlier in the differentiation pathway of the pleuripotential stem cell. Macrophages, neutrophils, and eosinophil's all respond to GM-CSF with proliferation and enhanced antibody dependent cellular cytotoxicity[2].

Summary and conclusion

An immunomodulator is any substance that helps to regulate the immune system. This "regulation" is a normalization process, so that an immunomodulator helps to optimize immune response. The immunomodulators do not tend to boost immune, But to normalize it.

Table 3. Various immunomodulators according to drug of choice in different diseases.

SN	DISEASE	DRUG OF CHOICE WITH DOSE
1.	Organ transplan-tation	Cyclosporine [10-15mg\kg for 1-2weeks]. Tacrolimus 0.10-0.15mg\kg\day in 2 divided doses. Azathioprine 3-10mg\kg for 1-2days for patients who do not respond to cyclosporine & prednisone. Mycophenolate mofetil 1g twice a day combined with steroids & cyclosporine.
2.	Lichen planus.	Triamcinolone acetonide 0.1% cream or ointment. Dexamethasone 0.5mg\5ml elixir for 2weeks. Systemic prednisone 40-80mg for 10 days. Topical tacrolimus 0.1% twice applications until lesion heals. Cyclosporine 8mg\kg\day for 8weeks or topical 5ml rinse TID, for 5weeks. Azathioprine 50-100mg\day adjuvant with steroid.
3.	Bullous pemphigoid and pemphigus.	Prednisone 5-60mg\day in di-vided doses for 1-2weeks. Cyclosporine 7.5 to 25mg\kg\ day for 6weeks. Tacrolimus 0.1% topical prepa-ration 2 times \day until lesions improved. Azathioprine 2-2.5mg\kg\day adjuvant with steroid.
4.	Rheumatoid arthritis.	Dexamethasone 4-20mg \day I.V.infusion. Azathioprine 1mg\kg\day as a single dose. Methotrexate 7.5mg weekly until symptoms improves.
	Bechet's syndrome.	a. cyclosporine 0.5-1mg\kg\day until lesions heals.
	Psoriasis.	Tacrolimus 0.05mg\kg\day for 3-6weeks. Methotrexate 2-5mg orally for 5days followed by a rest period of 2days or 10-25 mg intrave-nously weekly.
	Systemic lupus erythematous.	a. Azathioprine 2-3mg\kg\day until lesions heals.
	Apthous stoma-titis.	a. Triamcinolone acetonide 0.1% for 3-4times applications until lesions heals. b. cyclosporine 0.5-1mg\kg\day.

5.	Oral sub mucous fibrosis.	a. Intra lesional injections of dexamethasone 4 mg and hyaluronidase 1500IU for 7weeks bi weekly. b. Interferon gamma intra lesional] Injections. c. Levamisole 150mg thrice in a week for 4 weeks.
6.	Sjogren's syndrome.	Interferon alpha lozenges 150 IU per day thrice in a week for 12 weeks.
7.	Recurrent apthous stomatitis and herpes labials.	Levamisole 2.5 to 3mg\kg\day for 1-3months.

References

1. Goodman and Gilman's the pharmacological basis of therapeutics. Joel G. Hardman, Perry B. Molino of; 9th edition: 1291-1308.
2. A Lange medical book of basic and clinical pharmacology, Bertram G. Katzung; 8th edition: 959-985.
3. Essentials of medical pharmacology, K.D. Tripathi; 4th edition.
4. U. Christians and K-F. Sewing. Cyclosporine metabolism in renal patients. Journal of pharmacology theories 1993; 57: 291-344.
5. Text book of oral medicine. Burkett's; 11th edition
6. Text book of immunology. Ivan Roitt, Jonathan Brostoff, David Male; 5th edition
7. Michael A. Hooks. Tacrolimus, a new immunosuppressant- A review of literature; the annual of pharmacology 1994; 28:501-510.
8. J.B. Epstein, S. Nantel, S.M.Sheoltch. Topical Azathioprine in the combined treatment of chronic oral graft-versus-host disease. Journal of bone marrow transplantation 2000; 25: 683-687.
9. Essentials of medical pharmacology, K.D. Tripathi; 4th edition
10. Text book of pharmacology and pharmacotherapeutics, R.S. Satoskar; 17th edition.
11. Goldstein G. Mode of action of levamisole. Journal of rheumatology supplements 1978; 4: 143-8.
12. Karthikeva Patil, Mahima V.G, Shwetha Setty. Interferons- a review. JIAOMR 2005; 17: 03, 96-102.
13. Craig N. Burkhart, Lorie Gottwald, Lois Nelson. Tacrolimus and pimecrolimus; revolutionary new topical immunomodulators for skin disorders. Journal of international pediatrics 2004; 19: 7-11.
14. Goodman and Gilman's the pharmacological basis of therapeutics. Joel G. Hardman, Perry B. Molino of; 9th edition: 1233-1287.
15. Erik Letko, kailash Bhol. Review of Tacrolimus. Ann allergy asthma immunology 1999; 83: 179-190.
16. Sun, C-P. Chaig. Immunomodulation by levamisole in patients with recurrent aphthous ulcers or oral lichen planus. Journal of oral pathology and medicine 2009; 23: 172-177.
17. Penny A. Skaehil. Tacrolimus in dermatologic disorders. The annals of pharmacology 2001; 35: 582-587.
18. N. Rabinovitch, E.W. Gelfand, D.Y.M. Leung. The role of immunoglobulin therapy in allergic diseases. Journal of allergy and immunology 1999; 54: 662-668.

How to cite this article:

Sumalatha M N, Gadiputi Sreedhar and Jayavardhini P. (2026). Immunomodulators and their role in oral diseases- A Review. *Int J Recent Sci Res*.17(05), pp.704-711.

****