TITLE OF THE INVENTION

Methods of Modulating Cell Surface Receptors to Prevent or Reduce Inflammation

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of United States Provisional Patent Application Serial No. 60/757,751 filed January 10, 2006, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] The soft tissues of the mammalian oral cavity are known to exhibit the earliest indications of inflammation. This generalized low level of inflammation may lead to gingivitis and/or periodontitis. Such inflammation is generally believed to be the result, at least in part, by the bacteria present in the oral cavity. Further, oral tissue inflammation can be caused by surgery, localized injury, trauma, necrosis, improper oral hygiene or various systemic origins.

[0003] It is generally believed that the cellular components implicated by these diseases and conditions include epithelial tissue, gingival fibroblasts, and circulating leukocytes, all of which contribute to the host response to pathogenic factors generated by the bacteria. Some bacterial pathogens implicated in these oral infections are known although many may remain unknown or uncharacterized. Although the infection by certain types of bacteria is often the etiological event in many of these oral diseases, the pathogenesis of the disease state or condition is mediated by the host response. Use of antibacterial agents reduces the bacterial population of a given oral cavity and may result in a reduction of inflammation. However, this approach is disadvantageous as such killing is accomplished indiscriminately (both beneficial oral bacteria and deleterious oral bacteria may perish) and it is dose and time sensitive.

[0004] Bacterial infection of the oral tissue stimulates the host's immune response and diminishes the healing process by up-regulating inflammatory mediators that cause significant tissue damage. These metabolites have been implicated as the prime mediators in gingivitis, periodontitis, osteomyelitis and other inflammatory diseases.

[0005] It has been reported that one mechanism of inflammation is mediated through certain transmembrane receptors of mammalian cells. For example, toll-like receptors ("TLRs"), are glycosylated transmembrane proteins and once activated by ligand-induced oligomerization initiate an immune response within the cell, ultimately resulting in the expression of cytokines, interleukins, and other molecules that mediate the state of inflammation.

[0006] There is a need in the art for agents and techniques useful in the diagnosis, treatment, and prevention of such inflammatory effects.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1 is a schematic diagram showing a cell's surface in contact with a microbe.

[0008] Figure 2 shows the signaling pathways of toll-like receptors (TLR) 1, 2, 3, 4, 5, 6, 7 and 9, as well as the various molecules generated by the modulation of each TLR.

BRIEF SUMMARY OF THE INVENTION

[0009] The invention includes a method of distinguishing among oral bacteria species to determine whether a species is orally deleterious. Such method includes contacting at least one bacterium or portion of a bacterium of a species of oral bacteria a gingival cell; and detecting the presence of an indicator compound. The substantial absence of an indicator material signifies that the species of bacteria is not a deleterious species.

[0010] Also included within the scope of the invention are methods for determining the anti-inflammatory effect of an agent. Such methods include contacting the cell with the agent in the presence of a deleterious bacterium or portion of such bacterium and detecting the presence of an indicator compound. The substantial absence of an indicator material signifies that agent is an anti-inflammatory agent.

DETAILED DESCRIPTION OF THE INVENTION

[0011] The invention provides methods for (1) distinguishing among deleterious bacterial species and beneficial oral bacteria and (2) methods for determining the anti-

inflammatory effect of a specific agent. Also provided are methods of preventing the modulation of a toll-like receptor in a cell using triclosan.

[0012] "Inflammation" as used herein refers to the localized protective response elicited by injury or destruction of tissues that serves to destroy, dilute, or sequester both the injurious agent and the injured tissue. In the acute form, it may be characterized by pain, heat, redness, and swelling. Histologically, inflammation involves a complex series of events, including dilation of arterioles, capillaries, and venules, with increased permeability and blood flow; exudation of fluids, including plasma proteins, and leukocytic migration into the inflammatory locus. Inflammation corresponds to enhanced levels of pro-inflammatory cellular mediators, or substances that are released for example, as the result of the interaction of an antigen with an antibody or by the action of antigen with a sensitized lymphocyte. By extension, an anti-inflammatory agent is any that reduces the quality and/or quantity of these histological effects in a cell, relative to a like cell not treated with the agent.

[0013] The invention provides, in part, a method of evaluating a specific species or strain of bacteria in order to determine whether such species or strain is deleterious in the oral cavity. By "deleterious" it is meant pathogenic bacteria the presence of which results in generation of inflammatory mediators by the affected cells. Some strains/species of bacterial have been reported to be deleterious, including those of Table I, below:

Table 1: Oral Bacteria Reported to Be Deleterious

A. gerencseriae
A. naeslundii 1
A. naeslundii 2
V. parvula
S. mitis
S. oralis
C. gingivalis
C. sputigena
F. nucleatum ss nucleatum
F. nucleatum ss polymorphum
F. periodonticum
P. intermedia

T. forsythia
L. buccalis
N. mucosa
P. acnes
P. melaninogenica
S. noxia

[0014] The method includes contacting at least one bacterium of the species or strain of oral bacteria to be evaluated with at least one gingival cell. Alternatively, the gingival cell can be contacted with a portion of the bacterium, the cell membrane, the cytoplasmic contents, the bacterium's metabolic, end or by-products and/or virulence factors.

[0015] This step may occur *in vitro*, for example, by maintaining culture of bacteria or bacterial parts and of gingival cells and combining such cultures. Alternatively, the contact may occur *in vivo*, by application of the bacterial culture in an appropriate delivery vehicle to the oral cavity.

[0016] After such contact, one or more indicator material may be detected. Such indicator materials include any that are know or to be discovered that are generated by in the ordinary course of a host's immune response including intermediate compounds, enzymes, proteins, RNAs, DNAs, and other molecules that are involved in the cellular production of cytokines and other pro-inflammatory mediators. Preferred are indicator materials that are generated by the modulation of any of the toll-like receptors (*e.g.*, as shown in Figure 2), including, for example, TLRs 2, 3, 4, 5, 7, and 9; molecules of the NFk-B pathway, cytokines, interleukins (*e.g.*, 1, 6, 8, 12), tumor necrotic factor (TNF), peptidases, and mRNAs coding for the interleukin or TNF subunits and/or interleukins, chemokines (*e.g.*, CCL5, CCL4, CCL3, and CC10), and matrix metaloproteinases.

[0017] The detection of the selected indicator material may be carried out by in any manner known or to be developed in the art and may be a relative or an absolute measurement. Detection may be accomplished by direct measurement of the quantity of selected indicator material(s). Alternatively, it may be accomplished by indirect

measurement using additional detection systems, such as radioactive and/or fluorescent markers, antibodies, alterations in the level of gene expression of specific genes, mRNA analysis, microarray analysis, and/or changes in antioxidant status. For example, if the indicator material is an enzyme, one may subject the sample to an appropriate substrate and measure the end product of an enzyme-catalyzed reaction to determine the presence or absence of the enzyme indicator material. In the practice of this aspect of the invention, the substantial absence of the selected indicator material demonstrates that the species/strain of bacteria is not deleterious – *i.e.*, does not affect the cell in such as manner as to initiate the production of any pro-inflammatory mediators.

[0018] The invention also includes a method for evaluating the anti-inflammatory capacity or effect of a specific agent, *i.e.*, the capability of the agent to reduce or eliminate inflammation in a tissue exposed to a pathogenic bacterium. The method includes selection of an agent to be evaluated. Such agent may be a protein, peptide, organic molecule, inorganic molecule or conjugate of any of the same.

[0019] Under some circumstances, it may be desirable that the selected agent to be evaluated does not exhibit significant bactericidal effects in the oral context. For example, the agent may be selected from those that exhibit a Minimal Inhibitory Concentration (MIC) of 0, less than about 5%, less than about 10%, less than about 20% and less than about 30%.

[0020] MIC studies general include preparation of a solution of the active agent in an appropriate solvent and subsequent serial dilution of the solubilized active. A standard suspension of the selected bacteria (these could be a range of bacteria each of which requires its own specialized protocol for growth and handling) is added to each concentration of the diluted active. The bacteria + active are incubated under appropriate conditions at 37°C and bacterial growth monitored typically after 48 hours of incubation.

[0021] Controls for the MIC studies include a growth control that monitors bacterial growth in the absence of any added solvents or excipients. Additional controls

monitor the sterility of the media used for tests. The effects of the solvent(s) used to solubilize the active agents on bacteria are the final series of controls included for these studies.

[0022] Following incubation, the plates are read in a microplate spectrophotometer at 610 nm. Results are interpreted as the lowest concentration of the active agent that inhibits the bacterial growth. At high active concentrations, bacteria would not grow (shows as a low optical density reading) and at low active concentrations bacteria would proliferate (shows as a high optical density reading). The lowest active concentration to stop bacterial growth is defined as the MIC. The controls should come out as follows:

[0023] Sterility of media – no bacterial growth

[0024] Monitoring bacterial growth – the cultures show demonstrate luxurious growth

[0025] The solvents used to solubilize active agents should not inhibit bacteria (as they must be essentially innocuous).

[0026] The method of evaluating the anti-inflammatory capacity or effect of a specific agent includes the step of contacting a cell with a pathogenic or deleterious bacterium. The cell to be contacted may be *in vitro* or *in vivo*, prokaryotic or eukaryotic, and may be obtained from a cell culture line or a clinical sample.

[0027] Suitable pathogenic or deleterious bacteria for use in the method include any know or to be discovered in the art that affect the selected cell in such a way as to elicit an immune response. Such bacteria may include, for example, those listed in Table I, above.

[0028] The method of evaluating the anti-inflammatory capacity or effect of a specific agent includes the step of detecting the presence or absence of one or more indicator compound(s). Indicator compounds and detection methods and systems may be any of those described above.

[0029] Also included in the invention are oral formulations containing the agents found to exhibit an anti-inflammatory effect by the assay described above, as

well as methods of preventing the modulation of toll-like receptors on oral tissue cells by contacting such cell with triclosan.

[0030] The invention also provides methods of reducing or preventing inflammation of an oral tissue by application of a compound, such as triclosan, to the tissue at sub-MIC levels. By sub-MIC levels.

CLAIMS:

1. A method for determining the anti-inflammatory effect of an agent comprising contacting the cell with the agent in the presence of a deleterious bacterium or portion of such bacterium and detecting the presence of an indicator compound,

wherein the substantial absence of an indicator material signifies that agent is an anti-inflammatory agent.

2. The method of claim 1, wherein the cell is a eukaryotic cell.

3. The method of claim 1, wherein the cell is a prokaryotic cell.

4. The method of claim 1, wherein the indicator material is selected from the group consisting of molecules generated by the modulation of a toll-like receptor.

5. The method of claim 1, wherein the indicator material is selected from the group consisting of molecules generated by the modulation of TLR 2, TLR 3, TLR 4, TLR 5, TLR 7, and TLR 9.

6. The method of claim 1, wherein the indicator material is selected from the group consisting of molecules of the NF-κB pathway.

7. The method of claim 1, wherein the indicator material is selected from the group consisting of cytokines and interleukins.

8. The method of claim 1, wherein the indicator material is selected from the group consisting of IL-1, IL-6, IL-8, IL-12, and TNF-ά.

9. The method of claim 1, wherein the indicator molecule is detected directly.

10. The method of claim 1, wherein the agent is selected from agents exhibiting an MIC of less than about 20%.