Taurine: A Potential Mediator for Periodontal Therapy

Abstract
Taurine or 2-aminoethanesulfonic has many fundamental biological roles such as conjugation of bile acids, antioxidation, osmoregulation, membrane stabilization, and modulation of calcium signaling. It is essential for cardiovascular function and development and function of the skeletal muscle, the retina, and the central nervous system. Functions of taurine include osmoregulation; membrane stabilization; modulation of calcium levels; and antioxidation, antiapoptotic, anti-inflammatory, and antilipid activities. Taurine was first discovered as a component of ox (Bos taurus, from which its name is derived) bile in 1827; it had taken over a century before insights into its physiological functions were made. The present review throws light on the multifactorial properties of taurine and its potential to be used in periodontal therapy.

Keywords: Anti-inflammatory, antilipid action, antioxidant, periodontitis, taurine

Introduction
Taurine, or 2-aminoethanesulfonic acid, is an organic acid which is not utilized in protein synthesis, but rather is found free or in simple peptides. It is a major constituent of bile and can be found in the large intestine and accounts for approximately 0.1% of total human body weight. Taurine has many fundamental biological roles such as conjugation of bile acids, antioxidation, osmoregulation, membrane stabilization, and modulation of calcium signaling. It is essential for cardiovascular function and development and function of the skeletal muscle, the retina, and the central nervous system (CNS). While taurine is sometimes called an amino acid and, indeed, is an acid containing an amino group, it is not an amino acid in the usual biochemical meaning of the term, which refers to compounds containing both an amino and a carboxyl group.[1]

Taurine plays an important physiological and pathological role in various organs and tissue components. These include osmoregulation; membrane stabilization; modulation of calcium levels; and antioxidation, antiapoptotic, anti-inflammatory, and antilipid activities.[2-4] The antioxidant effects of taurine have been found to affect cell proliferation, inflammation, and collagenosis.[5] Topical formulation containing taurine with various concentrations enhances wound healing on the skin,[5] gingiva,[6] maxillary mucosa,[7] and periodontal tissue.[8] Taurine is necessary for normal cell differentiation and immune maturation.[5,9] Antioxidant and antiapoptosis effects of taurine improve wound healing, and it also prevents damage by oxidation on incisional skin wounds.[10]

Biochemistry and Metabolism
Taurine molecule contains a sulfonic acid group, rather than the carboxylic acid moiety found in other amino acids [Figure 1]. Unlike true amino acids, taurine is not incorporated into proteins and is one of the most abundant free amino acids in many tissues, including skeletal and cardiac muscle, and the brain.[3] In the body, taurine is synthesized from the essential amino acid methionine and its related nonessential amino acid cysteine. There are three known pathways for the synthesis of taurine from cysteine. All three pathways require pyridoxal-5-phosphate, the active coenzyme form of Vitamin B6, as a cofactor. A Vitamin B6 deficiency has been shown to impair taurine synthesis.[11] The activity of cysteine sulfinic acid decarboxylase, the enzyme which converts both cysteine sulfinic acid into hypotaurine and cysteic acid into taurine, is thought to reflect the capacity for taurine synthesis.[12]

Historical Background
Taurine was first discovered as a component of ox (Bos taurus, from which its name is derived) bile in 1827; it had taken over a century before insights into its physiological functions were made. The present review throws light on the multifactorial properties of taurine and its potential to be used in periodontal therapy.

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Functions of Taurine

Taurine as host modulatory agent
HOCI and TauCl which are the end products of the neutrophilic respiratory burst have been found to modulate the host inflammatory response by inhibiting the production of IL-6, prostaglandins, and other pro-inflammatory substances. Thus, HOCI and TauCl, playing a crucial role in the periodontal inflammatory process, offer opportunities for the development of novel host modulation therapies for the treatment of periodontitis.

Taurine in exercise
Taurine has been found to have a positive effect on the left ventricular function due to its regulatory role in intracellular Ca²⁺ homeostasis via its effect on voltage-dependent Ca²⁺ channels by the regulation of Na⁺ channels and via Na–Ca exchange and Na(+)–taurine cotransport. Hence, taurine modulates intracellular Ca²⁺ levels. Combined supplementation with branched-chain amino acid and taurine has been found to be a useful strategy for attenuating delayed onset muscle soreness and muscle damage.

Taurine in neuroprotection
Taurine release from different CNS cells is observed under pathophysiological conditions such as hypoosmotic stress, ischemia, or acute hyperammonemia, where its interaction with the receptors for inhibitory neurotransmitters such as gamma-aminobutyric acid and glycine plays a neuroprotective role.

Effect of taurine on osteoclastogenesis
Taurine has been found to inhibit osteoclastogenesis in the coculture of osteoblasts and bone marrow cells through the TAUT. Thus, taurine has been found to play a direct role in bone homeostasis by inhibiting osteoclastogenesis.

Role of taurine in modulation of Ca²⁺ levels
The effects of taurine and homocysteine on Ca²⁺ uptake, Ca²⁺-ATPase activity, and generation of hydrogen peroxide and superoxide anions in vitro in isolated rat myocardial mitochondria were studied. It was found that taurine (5, 10, and 20 mmol/L) promoted Ca²⁺ uptake in a concentration-dependent manner, as well as concentration dependently reducing the homocysteine (0.5 mmol/L)-induced inhibition of mitochondrial Ca²⁺ uptake. Taurine was also found to have a diphasic action on mitochondrial Ca²⁺-ATPase activity.

Properties

Antioxidant property
The useful effects of taurine as an antioxidant in biological systems have been attributed to its ability to stabilize biomembranes, to scavenge ROS, and to decrease the peroxidation of unsaturated membrane lipids. In addition, taurine scavenges HOCI produced by the activation of granulocytes, forming taurine chloramine, and thus may act as an indirect antioxidant. Taurine has also been found to exert a protective role against the oxidative stress in the management of patients with chronic periodontitis.

Anti-inflammatory property
Locally administered taurolidine (TRD) shows strong anti-inflammatory properties. In vitro, the effect of TRD and HOCl-treated TRD on peritoneal macrophages was compared with that of taurine-N-monochloramine (TauCl). TRD inhibits vascular permeability increased by inflammatory stimuli; it also significantly attenuates the influx of neutrophils into the peritoneal cavity, as well as the production of pro-inflammatory cytokines (tumor necrosis factor-alpha and interleukin 6 [IL-6]) by peritoneal exudate cells.

Anti-apoptotic property
Taurine has positive effects on bone metabolism. Taurine has been found to inhibit serum deprivation-induced osteoblast apoptosis via the taurine transporter (TAUT)/extracellular signal-regulated kinase signaling pathway. In this study, the effect of taurine on apoptosis of mouse osteoblastic MC3T3-E1 cells was evaluated and a reduction of MC3T3-E1 cell apoptosis induced by serum deprivation was observed.

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Clinical application in periodontics

It has been demonstrated that taurine can protect the heart from neutrophil-induced reperfusion injury and oxidative stress. Because the respiratory burst activity of neutrophils is also significantly reduced in the presence of taurine, perhaps taurine’s protective effect is mediated by its antioxidative properties.[26]

A study by Gültekin et al. in 2012[10] concluded that topical application of 1% taurine on the two basement membrane proteins (laminin 5 and type IV collagen expressions) of regenerating oral gingival epithelium demonstrated histologic evidence of rapid reepithelialization of human gingival wounds.

In a study by Sree and Sethupathy in 2014,[18] oxidative stress, the antioxidant status present in the gingival tissue and plasma of patients with chronic periodontitis and antioxidant property of taurine, was evaluated. It was concluded that taurine seems to improve the antioxidant status of chronic periodontitis patients by influencing the levels of lipid peroxidation products Thioibarbituric acid reactive substance (TBARS) and the antioxidant enzymes glutathione peroxidase and reduced glutathione.

Safety and Toxicity

Not much is known about the possible effects of taurine overdose, or if an overdose is even possible. Because the kidneys remove any excess taurine that is consumed, it may be difficult to take too much taurine. The Panel on Additives and Products or Substances used in Animal Feed estimates the observed safe level in humans to be 6 g/person/day (corresponding to 100 mg/kg body weight per day). In the absence of data, taurine is considered to be a skin and eye irritant and skin sensitizer and to be hazardous if inhaled.[28]

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Conflicts of interest

There are no conflicts of interest.

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