

Insidious Role of Diabetes Mellitus on Nerves and Dental Pulp

SARAMMA MATHEW FENN¹, MOHAN NARAYANAN², MATHEW JACOB³

ABSTRACT

Diabetes Mellitus is a metabolic disorder with deleterious effect on the physiological functioning of body systems. The predisposition of body organs and tissues to infections, nervous and circulatory dysfunction brands this disease with a wide spectrum of clinical manifestations. The present scenario in the management of patients with diabetes has shifted from symptom-specific treatment to a holistic approach in the overall treatment of soft and hard tissue pathologies presented by the disease. A deeper comprehension of the pathogenesis of diabetic complications, both general and local, can serve as an ally in rendering a “tailored” treatment which not only alleviates the symptoms but treats the underlying cause. This article addresses the generalised effect of hyperglycaemia and its insidious but progressive effect on the dental pulp.

Keywords: Anachoresis, Hyperglycaemia, Pulpal infections, Sensory nerve fibers

INTRODUCTION

Diabetes Mellitus is a clinically and genetically heterogeneous metabolic disease characterised by abnormally elevated blood glucose levels with dysregulation of carbohydrate, protein and lipid metabolism [1]. The gradual progression and insidious nature of the disease affect the physiological functioning of the body systems. The treatment of diabetes mellitus poses challenges in maintaining the normal level of blood glucose to delay the inevitable systemic complications. Among the body systems, the nervous and vascular systems are two of the earlier affected systems with severe debilitating consequences [2]. This article describes the effect of hyperglycaemia on the nervous system and the changes seen on the innervation of the dental pulp in diabetics.

Effect of Diabetes on Nerves

Loss of sensation in the extremities is one of the earliest complications to develop in diabetics. Diabetic patients have a high risk of developing neuropathy and elicit varying neurological symptoms such as numbness, dysesthesia, increased pain during the night, to loss of sensation with the progression of disease [3]. As a result, diabetics frequently present with painless ulcerations in lower limbs discovered as an incidental finding [4]. However, the relation of vascular abnormalities and nerve fibres deterioration is still being investigated. Development of abnormalities in vascular channels such as capillary basement membrane thickening, endothelial hyperplasia with diminished oxygen tension and hypoxia reduce the nerve conduction velocities resulting in decreased peripheral nerve sensation [5]. The link between vasculopathy and neuronal fibre degeneration are found to be proportional to the malfunctioning of the pancreatic gland and glycaemia. Regardless of the type of diabetes, it has been observed that all the aspects of the nervous system are eventually affected, with the sensory and autonomic system to be greatly affected than the motor system [6].

The duration and hyperglycaemic level correlate to the severity and damage to the nervous tissue. Diabetic neuropathy is mainly due to the alteration in the sorbitol or polyol pathway. The polyol pathway converts glucose to fructose utilising the enzymes aldose reductase and sorbitol dehydrogenase thereby reducing the accumulation of sorbitol within the cell. The failure of the enzymes results in deposition of sorbitol in the cell causing hypoxia leading to nervous tissue ischaemia [7]. Also, studies have shown the possibility that genetic alteration of the aldose reductase gene may also play a

role in the nervous system damage in diabetics [8-11]. It has been shown that the longer nerves exhibit earlier loss of nerve sensation in diabetics. However, in the pulp, the long nerves demyelinate to form a plexus beneath the odontoblasts which extend their bodies into the dentin and by the hydrodynamic mechanism provide sensory perception. This unique sensory mechanism has been postulated to be affected in diabetes patients due to several factors such as increased inflammatory mediators, thickening of basement membrane and hampered collagen synthesis [12].

Oral Complications

The chronic elevation of blood glucose has shown to bring about long-term damage to vital organs including the oral cavity. The classical features of uncontrolled diabetes include a wide spectrum of oral manifestations such as xerostomia, opportunistic fungal infections and periodontitis. Several studies have shown a reduced salivary flow rate in patients with HBA1c greater than 7%, signifying an association of salivary gland function and low glycaemic control [13-15]. The effect of polyuria and hyperglycaemia on salivary gland parenchyma hampers the saliva production. The volume of fluid decreased in the extracellular component occurs due to polyuria, consequently reducing the volume of saliva and increasing the viscosity preventing the mechanical flushing action on retentive cariogenic bacteria residing on the surface of the tooth [16].

The normal salivary glucose (0.5-1.00 mg/100 mL) do not significantly affect oral health but higher values of salivary glucose favour the proliferation of microorganisms and enhance their colonisation on teeth and oral mucous membrane. Moreover, an increased level of glucose in saliva and crevicular fluid occurs due to an ineffective filtration of glucose from blood thus increasing the incidence of dental caries [17,18]. Altered taste sensation, one of the early signs of diabetic neuropathy, is an indicator of fluctuation in blood glucose levels and is a consequence of alteration in the taste bud receptors for glucose moieties [19].

Diabetes and Dental Pulp

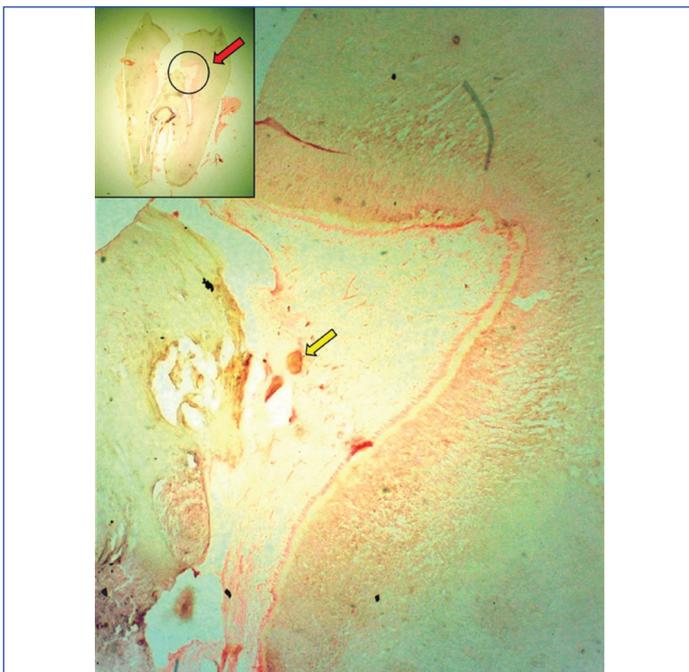
Diabetes mellitus has a direct effect on the structural components of dental pulp. In a study conducted on diabetes-induced rats, histologically evident changes were observed in the structure and function of the blood vessels supplying the dental pulp. The morphometric analyses on these rats showed a significant reduction in volumetric density of collagen fibres and fibroblasts around blood vessels contributing to the progression of pulpal and periapical

infections [20]. In uncontrolled and long-standing diabetics the dental pulp showed significant reduction in the blood flow of pulp due to thickening of the basement membrane of the blood vessel and reduced collateral circulation. With increased cell mediators such as kallikrein-nitrite levels in dental pulp, a diminished leukotactic response cause pulpal inflammation and irreversible damage (necrosis) to the dental pulp [21]. These changes in vasculature also reduce the oxygen supply and overall oxygen saturation favouring an environment for proliferation of anaerobic bacteria [22].

“Multifaceted” is one word that aptly describes the physiological functioning of the sensory nerve supplying the tooth. The uniqueness lies in the fact that innervation of the dental pulp not only provides innervation for sensation, but also protection and repair. The sensory innervation is performed by the polymodal nociceptors that respond to thermal, mechanical and chemical stimuli primarily by the myelinated A-delta and the partially unmyelinated C-fibres through the dentinal fluid dynamics. It has been observed that the nerves of the tooth undergo structural and morphological changes during inflammation in the dental pulp (visualised under an electron microscope) with fibres that slip between the odontoblastic bodies, twist around the tubules sprouting nerve fibres which express strong positivity of S100 markers for macrophages or dendritic cell [23].

Numerous studies have established a significant correlation between high blood glucose levels and duration of diabetes on the nervous system [24]. The peripheral nerve cells in diabetics’ undergo glycosylation exerting direct toxicity on the nerves along with endoneurial microangiopathy. Increase in glucose entry within a cell cause release of oxidants in mitochondria leading to reduced mitochondrial action potential with poor energy synthesis decreasing the overall conduction potential of nerves. These are clinically translated as decrease in response to any stimuli by electrical stimulation in dental pulp or stimuli to vibration or touch in the peripheral parts of the body [25].

Pulp stones are age-related physiological calcifications frequently identified in pulp chambers of elderly. Pulp stones of diabetics are more prone to such calcifications and have been linked to elevated hyperglycaemia, duration of diabetes and late diabetic vascular changes in uncontrolled diabetics [26,27] [Table/Fig-1]. Another distinct feature is the “Sickle” shaped appearance of the pulp stones when compared to globular or spherical laminations or stratifications observed in non-diabetics [28].

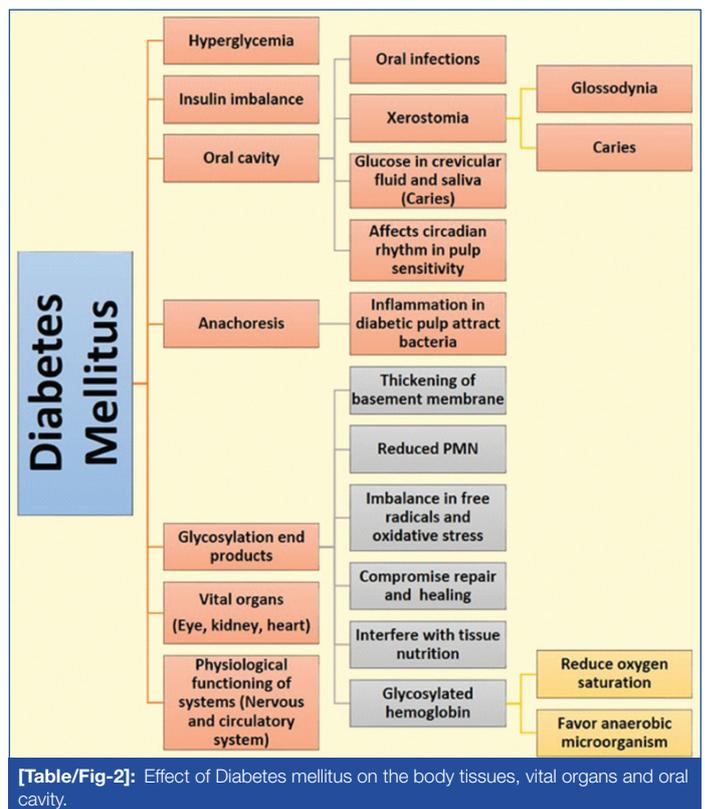


[Table/Fig-1]: Longitudinal Ground Section of permanent molar (Inset) showing a Decalcified section of tooth with Pulp stone (Yellow arrow).

Predisposition to Caries, Pulpal Infections and Periodontitis

Pulp of unrecognised diabetes and uncontrolled diabetes are always in a state of perpetual inflammation due to impairment in sensory nerve activity and microcirculation causing necrosis of pulp. “Diabetic odontalgia” is a condition frequently encountered in diabetic patients with longstanding hyperglycaemia presenting with symptoms of pain similar to pulpitis but in absence of caries. The condition usually affects a single tooth however cases with multiple teeth involvement in two or more quadrants have also been reported. Such patients may also exhibit a negative response in electric pulp testing for vitality. These conditions are often resolved when patients are treated for the underlying unrecognised diabetes and usually the pulpal infections subside when insulin therapy is initiated with a favourable response to endodontic treatment [29].

Apart from the crown, the other means by which cariogenic bacteria access the pulp is by the process known as Anachoresis. By this route, microorganisms present in the bloodstream from other sources along with the toxins end up in the pulp inducing pulpal and periapical inflammation in diabetics [Table/Fig-2]. These bring about asymptomatic pulpal and periapical infections described by Bender IB et al., [28]. Numerous case reports have also observed in unrecognised cases of diabetes a higher prevalence of periapical pathosis, osteolytic lesions and delay in periapical repair without any clinical or radiographic evidence of caries [30-32].



[Table/Fig-2]: Effect of Diabetes mellitus on the body tissues, vital organs and oral cavity.

There are many factors identified for loss of teeth in diabetics and advanced glycation products in gingiva and periodontium have been identified as the primary reason of weakening of the attachment of root to the socket wall. The other reason is the reduced function of neutrophils promoting periodontal disease when compared to healthy individuals [33]. Diabetes is a risk factor for severe periodontal disease as the periodontopathic organisms amplify the magnitude of the advanced glycation end product-mediated cytokine response in diabetes mellitus [34].

CONCLUSION

In a nutshell, the “silent killer” disease is a challenging scenario for dentists as patients with diabetes often report in advanced stages of caries or periodontal diseases due to delayed response. The

mechanism of this systemic disease, the effect of diabetes on the innervation of the tooth and surrounding structures has to be understood by the dentist for effective management and treatment.

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PARTICULARS OF CONTRIBUTORS:

1. Senior Lecturer, Department of Oral Medicine and Radiology, Vinayaka Mission's Sankarachariyar Dental College, Vinayaka Mission's Research Foundation (Deemed to be University), Salem, Tamil Nadu, India.
2. Professor and Head, Department of Oral Medicine and Radiology, Vinayaka Mission's Sankarachariyar Dental College, Vinayaka Mission's Research Foundation (Deemed to be University), Salem, Tamil Nadu, India.
3. Reader, Department of Oral Pathology and Microbiology, Vinayaka Mission's Sankarachariyar Dental College, Vinayaka Mission's Research Foundation (Deemed to be University), Salem, Tamil Nadu, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Saramma Mathew Fenn,
Department of Oral Medicine and Radiology, Vinayaka Mission's Sankarachariyar Dental College,
Vinayaka Mission's Research Foundation (Deemed to be University), Salem, Tamil Nadu, India.
E-mail: docere_saramathew@yahoo.co.in; drsarammathewfenn@vmsdc.edu.in

Date of Submission: **Sep 12, 2018**

Date of Peer Review: **Oct 03, 2018**

Date of Acceptance: **Jan 15, 2019**

Date of Publishing: **Mar 01, 2019**

FINANCIAL OR OTHER COMPETING INTERESTS: None.