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Article

Periodontitis Histopathological Analysis and Its Correlation to the Biochemical Parameters in Oxidative Stress

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Abstract: Purpose: Researchers in this study set out to determine if periodontal disease patients' saliva had any histological alterations or oxidative stress. Materials and Methods: In our study, we compared two groups of periodontitis patients, one with stage I and another with stage II, using saliva and serum samples. We also included a group of 15 volunteers who had no dental restorations. We used the thiobarbituric acid technique to dose malondialdehyde MDA and Ravin's method to determine ceruloplasmin. The periodontal fragments were prepared for histopathological analysis by quickly fixing them in 10% neutral formalin. Then, they were embedded in paraffin according to the standard histology protocol. Results: Patients in the second stage of periodontitis had lower salivary MDA readings than those in the first stage. Compared with the control group, patients with stage I periodontitis had a much higher blood concentration of MDA; however, in individuals with stage II periodontitis, this concentration was much lower. In the control group, there are no statistically significant differences in serum ceruloplasmin levels between patients with periodontitis stage II and those with periodontitis stage I. Conclusions: Since there is a greater concentration of malondialdehyde (MDA) in the circulation than in saliva, it cannot be a byproduct of blood filtering. There is a robust relationship between biochemical factors and tissue changes. Plaque removal from teeth helps keep mouths healthy.

Keywords: periodontitis, malondialdehyde, and ceruloplasmin.

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Introduction

Alveolar bone and periodontal ligament deterioration are hallmarks of periodontitis, a chronic inflammatory disease that supports teeth. Its main etiologies are oral microbiome dysbiosis, an inappropriate immune response, and tissue mutilation. Recent studies have demonstrated that oxidative stress is a major contributor to periodontitis pathophysiology; furthermore, reactive oxygen species (ROS) play an important role in mediating damage within tissues and inflammation among tissues (1,2). Histopathological analysis of periodontal tissues from periodontitis patients shows marked changes, including increased inflammatory cell infiltration, collagen degradation, and bone resorption (3). Reduced antioxidant enzyme activity and increased levels of oxidative stress indicators, such as malondialdehyde (MDA), are correlated with these alterations (4). The imbalance between the production of reactive oxygen species (ROS) and antioxidant defences not

only worsens damage to periodontal tissue but also leads to systemic health problems like diabetes and heart disease. (5). The degree of periodontal disease is inversely correlated with biochemical indicators, such as blood levels of antioxidant enzymes, including glutathione peroxidase (GPx) and superoxide dismutase (6). Figuring out how oxidative stress markers and histopathological findings are related could help create personalised treatment plans and give us more information about what causes periodontitis. To better understand this intricate disease process, this article will examine histopathological alterations associated with periodontitis and their relationship to biochemical markers of oxidative stress. The purpose of this study was to ascertain whether there were any histological changes or oxidative stress in the saliva of individuals with periodontal disease.

Materials and Methods

Two groups of patients were examined:

- Sixteen individuals with stage I periodontal disease, aged between thirty and fifty years;
- Sixteen individuals with stage II periodontal disease, aged between thirty and seventy years.

Saliva and serum samples have been used to analyse oxidative stress. By administering MDA dosed with thiobarbituric acid and ceruloplasmin according to Ravin's approach, the oxidative aggressiveness has been seen. A group of 15 volunteers who did not receive dental restorations served as a control group for the comparison.

Microscopical analysis

Histological examination of periodontal tissue samples necessitated their rapid fixation in a neutral formalin solution containing 10%. It took 6-12 hours for the periodontal tissues to be fixed. After that, the standard histological technique of paraffin embedding was used. A microtome was used to slice four pieces with a thickness of μm. A variety of staining procedures were used on different regions, including Hematoxylin-Eosin (HE), Masson's trichrome, Van Gieson, and restituin. We captured the photographs with a Nikon camera and examined the slides using a Nikon E600 microscope.

Statistical analysis

To analyze the data, the mean ± standard deviation (SD) was calculated, and Student's t-test was used with a statistical significance level of 0.05 for the p-value.

Results

In a study with a p-value of 0.001 or less, researchers found that salivary MDA levels were substantially higher in patients with stage 1 periodontitis than in the control group (0.62±0.12 nmol/mL vs. 2.34±0.28 nmol/mL).

Additionally, in comparison to the control group (0.62±0.12 nmol/mL), individuals diagnosed with stage II periodontitis had a significantly elevated MDA level (2.11±0.32 nmol/mL) ($p<0.001$). The salivary MDA levels of the individuals with stage II periodontitis were somewhat lower (2.34±0.28 nmol/mL vs 2.11±032 nmol/mL) ($p>0.1$) as compared to the group with stage I periodontitis.

Serum levels of malondialdehyde (MDA) were much higher in the group with stage I periodontitis than in the control group. Levels ranged from 2.62±1.31 nmol/mL for stage I to 4.28±0.27 nmol/mL for stage II, with a p-value>0.1, indicating a significant difference in concentrations between persons with stage I and stage II periodontitis.

Patients with stage II periodontitis had markedly elevated malondialdehyde (MDA) levels, ranging from 1.91±0.33 nmol/mL to 4.28±0.27 nmol/mL, compared with the control group ($p<0.001$). In contrast to the significantly decreased levels of 1.11±0.66 mg% ($p<0.001$) seen in the stage II periodontitis group, the control group exhibited salivary ceruloplasmin levels of 3.19±0.99 mg%.

The concentration of ceruloplasmin is low in individuals with stage I periodontitis, although it is not statistically different from that of the control group ($p>0.1$): 3.19±0.99 mg% to 2.14±1.18 mg%. Ceruloplasmin levels were not significantly different between patients with stage I and stage II periodontitis ($p>0.1$). Serum ceruloplasmin levels did not differ significantly among the control group, patients with stage II periodontitis, and patients with stage I periodontitis.

Histopathological results

Figure 1 shows that the body initiates an inflammatory reaction right away, which widens the small blood vessels, speeds up the migration of polymorphonuclear cells, and increases the flow of crevicular fluid because the blood vessels are more permeable (Figure 1-A).

As inflammation advances from gingivitis to periodontitis, the first histological indicator is its presence in the supra-alveolar connective tissue, situated under the base of the junctional epithelium (Figure 1-B). Within the inflammatory infiltrate, one may see plasma cells, many macrophages, and T-lymphocytes.

Figure 2-A shows locations of unequal hyperplasia and rete ridge formation, as well as areas of alternating thinning and open ulceration. Figure 2-B shows that there is a considerable migration of PMN and a huge enlargement of the subjacent connective tissue arteries.

There is a heavy infiltration of proliferative connective tissue beneath by inflammatory cells, mostly plasma cells, granulation tissue, and a profusion of new capillaries.

Collagen fiber bundles make up the majority of gingival overgrowth, while fibroblasts and scattered chronic inflammatory cell infiltration are also seen Figure 3-A. Pictured on the often hyperplastic epithelial surface are many collagen fibers and long, thin rete processes that extend into the underlying connective tissue (Figure 3-B).

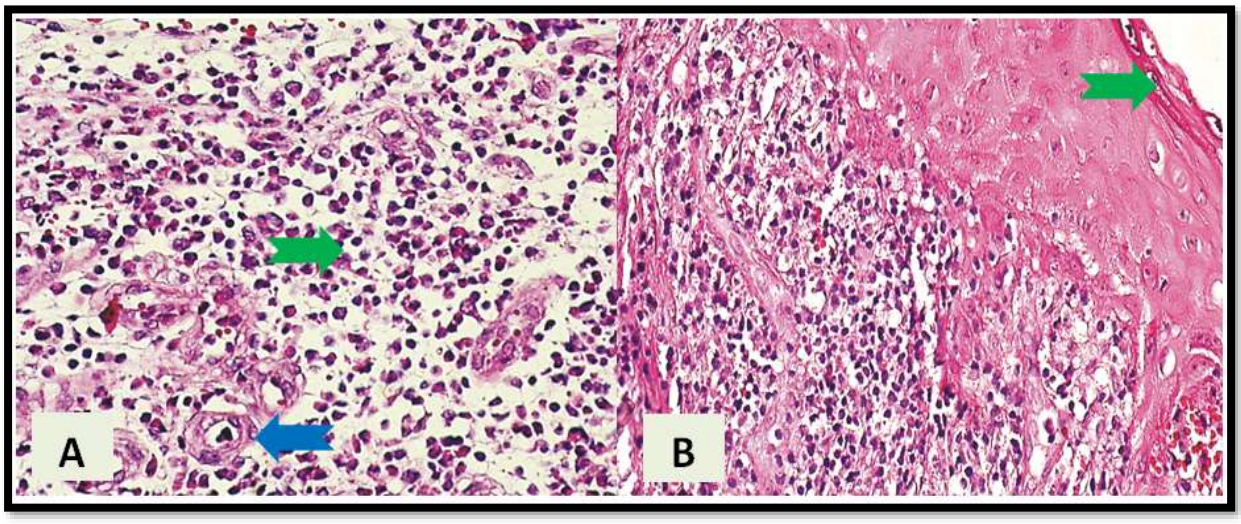

Figure 1-A – H&E staining at 200×reveals dilated and congestive arteries (blue arrow), as well as inflammatory cells in the chorion, including granulocytes, lymphocytes, and plasma cells (green arrow), indicating acute gingivitis. **B** – Congested blood vessels, subacute inflammatory infiltration in the chorion (lymphocytes, neutrophils, histiocytes),

and superficial keratinization (green arrow) are symptoms of subacute periodontitis. The HE staining at 100× further confirms these findings.

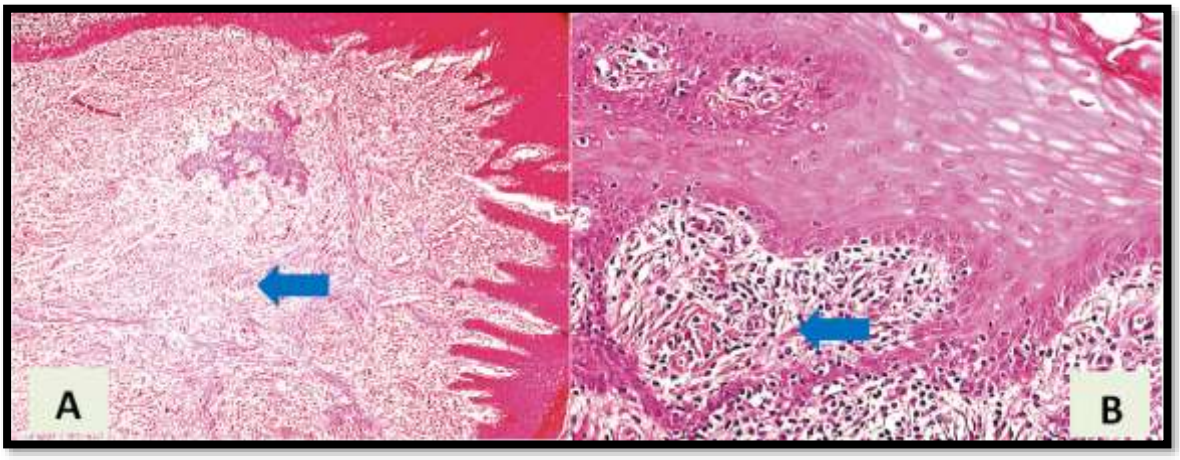

Figure 3-A – Chronic periodontitis characterized by papillomatous hyperplasia of the epithelial layer and keratinization in the chorion; inflammatory cells and hazy fibrosis(arrow) are seen surrounding it (HE staining, 40×). **B**- Granulation, chronic inflammatory cells in the chorion (arrow), and gingival epithelial layer with hyperplasia (HE staining, 200×).

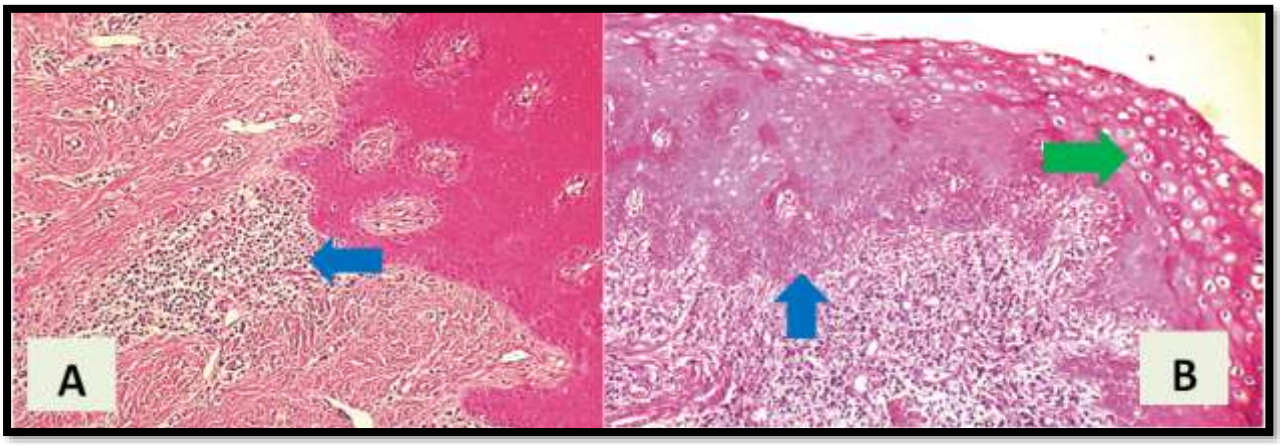

Figure 3-A – gingival epithelium papillomatous hyperplasia accompanied by superficial keratinization, persistent chronic inflammatory cells (blue arrow), and connective tissue proliferation (HE staining, 100×). **B**-The gingival papilloma's (blue arrow) chorion contains granulation tissue, acanthosis, and kilocytes (green arrow) (HE staining,100x)

Discussion

The multifactorial chronic inflammatory illness known as periodontitis is typified by the breakdown of the teeth's supporting tissues, including the alveolar bone and periodontal ligament (7). The interplay between microbial factors, the host immune response, and oxidative stress plays a significant role in the pathogenesis of this disease (8). Our recent results align with those of Herrera et al. (2026), who enhance the knowledge of these dynamics by investigating histological alterations related to periodontitis and their association with biochemical markers suggestive of oxidative stress. (9).

Our investigation revealed that patients with periodontitis stage I exhibited significantly higher blood concentrations of MDA than the control group (10). The well known marker of oxidative stress and lipid peroxidation is malondialdehyde,so individuals with perodontitis especially in early stages show elevated levels of oxidative

stress results in inflammatory processes in individuals of periodontal diseases.This elevation of MDA levels especially in stage I individuals with perodontal diseases reflect response to oral microbiome dysbiotic features,which subsequently triggers cascades of inflammation that results in exacerbation of tissue destruction. (11-12).

The results of this study showed that patients with stage II periodontal diseases have lower salivary levels of MDA than patients with stage I.This may be to adaptive mechanism for persistent inflammatory processes.This may be due to two reasons.The changed balance between oxidative and inoxidative processes, or may be due to the elevated immune response and defense mechanism when the periodontitis worsened. In pronlonged reaction of oxidative stress,the metabolic pathway in the body may alterd by less MDA synthesis.This adaptive response of has illustrated in many research.(13.14)

Ceruloplasmin, an acute-phase protein that plays a role in iron metabolism and antioxidant defense, is often elevated in inflammatory conditions(15).The lack of statistically significant differences in serum ceruloplasmin levels among the control group, stage I, and stage II periodontitis patients presents an intriguing aspect of our findings. The absence of variation in ceruloplasmin levels may indicate that systemic oxidative stress is not uniformly reflected in this protein's concentration, suggesting a complex relationship between local tissue responses and systemic biochemical markers. This complexity highlights the need for a more nuanced understanding of oxidative stress in periodontal disease.

Histopathological analysis of periodontal tissues from patients with periodontitis revealed significant alterations, including increased inflammatory cell infiltration, collagen degradation, and bone resorption. These findings are consistent with the established understanding that oxidative stress contributes to tissue destruction in periodontitis (16). The infiltration of inflammatory cells, such as neutrophils and macrophages, is a hallmark of periodontitis and is closely associated with the production of reactive oxygen species (ROS) that further exacerbate tissue damage. The observed collagen degradation reflects the destructive activity of matrix metalloproteinases (MMPs), which are upregulated in response to oxidative stress and inflammation(17,18).

Furthermore, the relationship between oxidative stress and systemic health issues, such as cardiovascular diseases and diabetes, emphasizes the broader implications of periodontitis beyond oral health. The systemic effects of periodontal disease, mediated by oxidative stress, suggest that managing periodontal health could have far-reaching benefits for overall health(19).

In conclusion, our study highlights the critical role of Oxidative stress has a role in the development of periodontitis, as shown by the link between alterations in histopathology and biochemical markers, including MDA and ceruloplasmin. The dynamic interaction between oxidative stress and inflammatory responses in periodontal tissues provides significant insights into the processes driving periodontitis development. Subsequent investigations have to concentrate on clarifying these pathways and examining prospective therapy strategies aimed at oxidative stress to enhance results for individuals with periodontitis.Understanding these relationships will be essential for developing personalized treatment strategies that not only address periodontal disease but also consider the systemic implications of oxidative stress.

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