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Histological Aspects Regarding Dental Pulp of Diabetic Patients

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Abstract: Background: The possible histological changes in dental pulp in teeth of diabetic patients are important to be understood, as the clinician will consider the best treatment choice for those teeth, especially if they are affected by decay. The aim of this paper is to assess if there are effects of diabetes-associated hyperglycemia on the nervous and vascular system of the dental pulp. Methods: Twenty-three dental pulp specimens of patients aged 36–70 years old were analyzed. All patients had been diagnosed with type 2 diabetes for at least 5 years. Results: Most of the patients had poorly controlled hyperglycemia, deep caries, but no clinical signs of pulpitis. The histological aspects of pulp specimens included frequently seen inflammatory infiltrate, degeneration of the nerves, thickened blood vessel walls, pulp sclerosis and frequent pulp calcifications, and even small necrotic areas. Conclusion: The analyzed dental pulp specimens of carious teeth of type 2 diabetic patients show fibrotic transformation of the dental pulp, with the presence of calcifications, arteriosclerosis and inflammatory infiltrate. In this situation, the attitude of the dentist in pulp vitality preservation in the case of carious teeth of diabetic patients should be limited.

Keywords: diabetes; dental pulp; caries; pulp sclerosis; pulp calcifications

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1. Introduction

The relation between diabetes and periodontal condition has been well studied, with a bidirectional relation between these pathologies having been proved [1]. Some authors have suggested that periodontal disease could be considered the sixth complication of diabetes [2], together with microvascular or macrovascular pathology, increased susceptibility to infections and delayed healing [3–5]. Because the nerves and blood vessels could be affected earlier due to diabetic complications [6,7], the assessment of dental pulp condition could be important for dental practitioners for the therapeutical approach toward carious teeth. Previous studies [8] suggested that the terminal innervation could be affected in diabetic patients. Additionally, blood flow in the dental pulp seems to be reduced, which could lead to reduced local oxygen supply and dental pulp inflammation, followed by necrosis of the dental pulp [9,10].

Pulse-oximetry was proven to be a reliable method to assess pulp vitality, but it cannot offer details about the dental pulp level of oxygen in the cases of patients with systemic pathology, such as diabetes [11]. A study on diabetic rats showed that histologic changes occur in their dental pulp, in terms of the reduction in collagen fibers and fibroblasts around blood vessels, which favored the progression of an endodontic infection [12].

Pulp denticles are usually age-related calcifications, frequently identified in pulp chambers or root channels of the elderly. Previous studies have shown that the dental pulp of diabetics is more susceptible to such calcifications and has been linked to elevated hyperglycemia, duration of diabetes and possible diabetic vascular changes in uncontrolled diabetics [13,14]. Moreover, the shape of these denticles in diabetics is different (sickle) to those of non-diabetics (spheroid), according to previous histologic observations [15].

Previous studies have shown that the success of vital pulp therapy depends on the capping material [16], and also on the oxygen and nutrient supply of dental pulp cells [17,18], which could be affected by the diabetes-induced vascular changes. In this situation, it is important to find the best treatment option for the carious teeth of diabetic patients.

Because the dental pulp is a built-in organ, it is impossible to assess its structure and functionality without damaging it. Therefore, few studies about the influence of diabetic vascular and nervous changes on the dental pulp are available. The aim of this paper is to assess, histologically, the effects of diabetes-associated hyperglycemia on the nervous and vascular system of the dental pulp. These findings might be of help for dentists to reconsider conservative therapy of teeth affected by decay in the case of diabetic patients.

2. Materials and Methods

For the purpose of the study, we selected an initial sample of 29 patients with diabetes mellitus (2 patients with type 1 diabetes, 27 patients with type 2 diabetes). The inclusion criteria were:

- the onset of diabetes from minimum 5 year period;
- patient was following daily antidiabetic treatment;
- no other known systemic pathology was reported;
- lack of bone loss due to periodontal disease to the selected teeth;
- the presence of extended carious lesions, without any clinical sign of pulpitis;
- the treatment plan of those carious teeth was vital extirpation for coronal reconstruction.

For the final study group we excluded the patients with type 1 diabetes ($n = 2$) because of their low number. Additionally, 4 dental pulp specimens from patients with type 2 diabetes were not prepared for histological analysis because they did not show objective signs of vitality (no bleeding was noticed).

Thus, the final study included 23 dental pulp specimens of 23 patients with type 2 diabetes mellitus. The age group of patients was 36–70 years old. Dental pulp specimens included in the analysis were obtained during vital pulp extirpation of selected carious teeth. The patients did not have clinical signs of pulpitis at the moment of pulp extirpation, the endodontic treatments were performed before prosthetic restoration of the teeth, which had extensive coronal destruction due to decay.

The patients were informed about the dental treatment and they signed an informed consent to agree to the treatment plan and the use of their data and their dental pulp specimens for the study. Because dental pulp is highly aggressed during dental treatment and is built into an organ-like structure–dentine–pulp complex, we tried not to affect this structure while collecting the soft tissue, and we collected the dental pulp with the tire-nerf needle during the pulp extirpation procedure.

The dental pulp tissue specimens were immediately fixed in formalin 10% for 48–72 h. The volume of fixing solution was 30–35 times bigger than the volume of the tissue specimen. After 48–72 h, the specimens were washed with water for 24 h to remove the formalin traces from tissue, and then embedded in paraffin. This way, it was possible to obtain 5-microns-thickness sections to be analyzed. The steps followed for the specimen's preparation were: dehydration, clarification, imbedding in paraffin, block sectioning, staining, drying the histological specimens. For the histological study, we used the Hematoxylin–Eosin (HE). The specimen's aspects were studied with a microscope and then analyzed.

3. Results

In total, 23 dental pulp specimens of 23 type 2 diabetic patients were evaluated, among them, 80% were women, 42% of the patients were aged between 36–55 years, and 58% were aged between 56–70 years old.

We compared the histological aspects of dental pulp specimens of type 2 diabetic patients with the image of the pulp of a healthy 47 year old female, with no clinical signs of pulpitis (Figure 1). In her case, the dental pulp was extracted before the prosthetic preparation of the tooth.

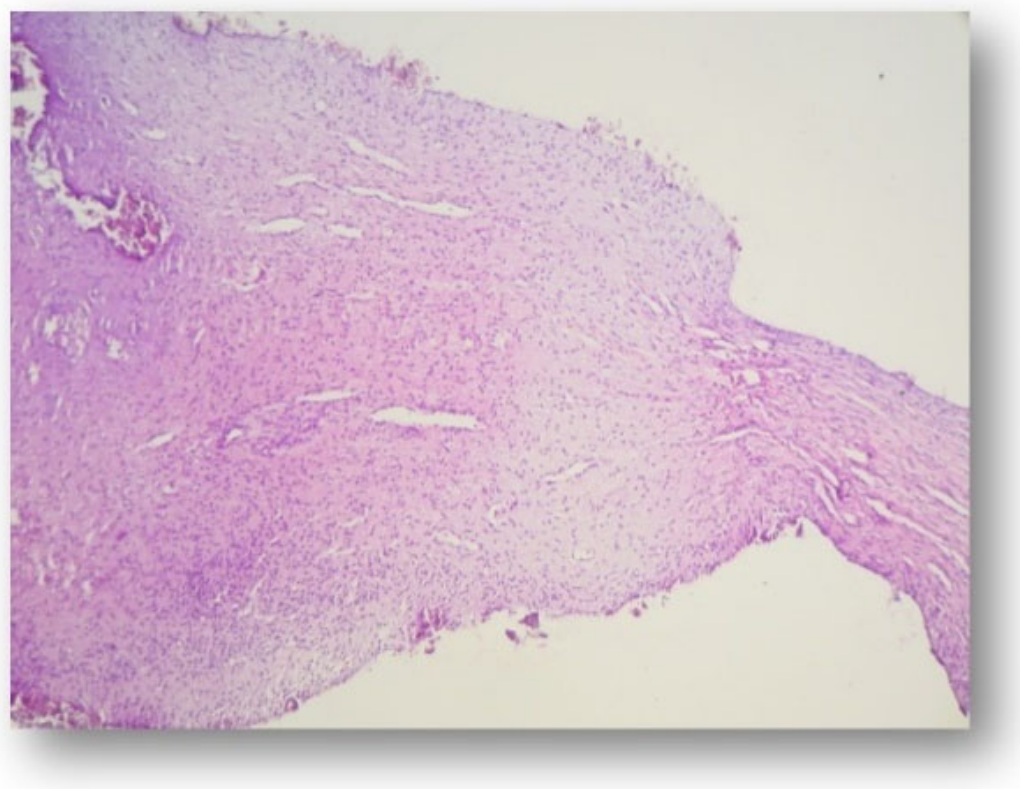

Figure 1. The corono-radicular pulp tissue of a healthy 47 year old female, with discrete leukocyte infiltration, few areas of sclerosis, HE staining, ×100.

The histopathological study of the dental pulp specimens obtained from patients with diabetes showed the presence of chronic or acute inflammatory infiltrate, mainly formed by neutrophils, plasma cells and macrophages. Inflammatory infiltrate appeared most often diffused, dissociating the collagen fibers from the dental pulp. In some cases, the inflammatory infiltrate was much more abundant or associated with pulp microcalcifications.

Eight of the histological specimens analyzed are presented below.

Figure 2 shows the aspect of the dental pulp of a 36 year old male with type II diabetes since 2015, Hb 193 mg/dl and HbA1c 7.3%. Despite the young age of the patient, the histological aspect of the dental pulp shows diffuse inflammatory infiltrate, fibrosis and small dystrophic calcifications, with numerous neutrophils, relative few eosinophils, lymphocytes and plasma cells.

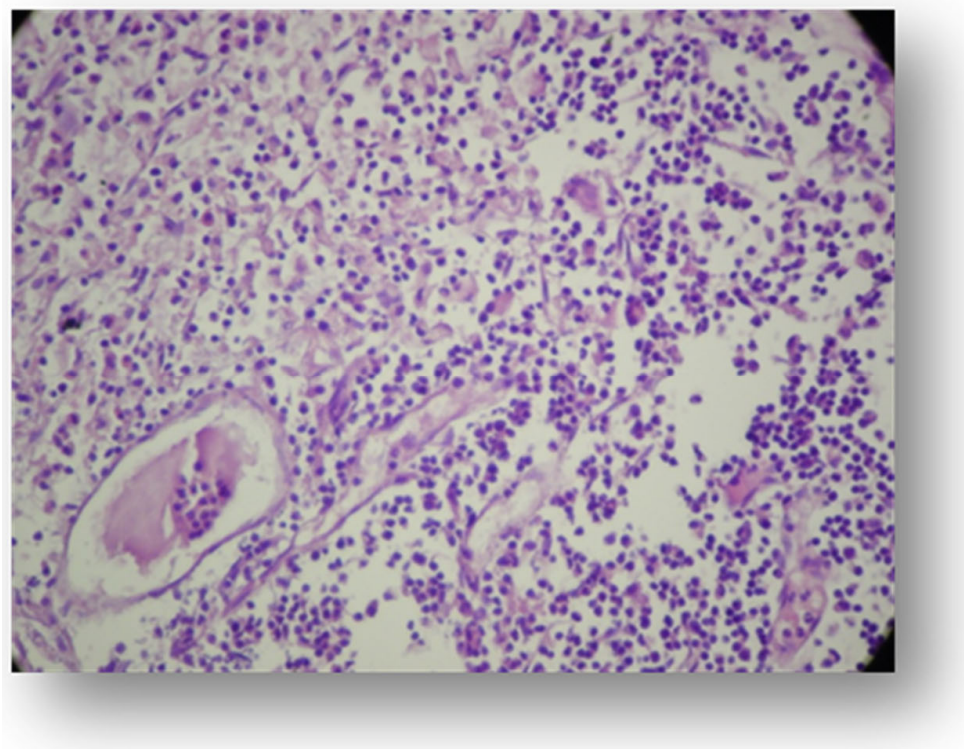

Figure 2. Dental pulp aspect (coronal) of a 36 year old male, type 2 diabetes, HE staining, ×200.

Figure 3 illustrates the histological aspect of the dental pulp of a 47 year old female with type II diabetes from 2009, with Hb 188 mg/dl and HbA1c 6.9%. Pulp sclerosis is present with few inflammatory cells, thickened walls of blood vessels, dystrophic calcifications and degeneration of the nerves, probably due to the development of the chronic inflammatory process.

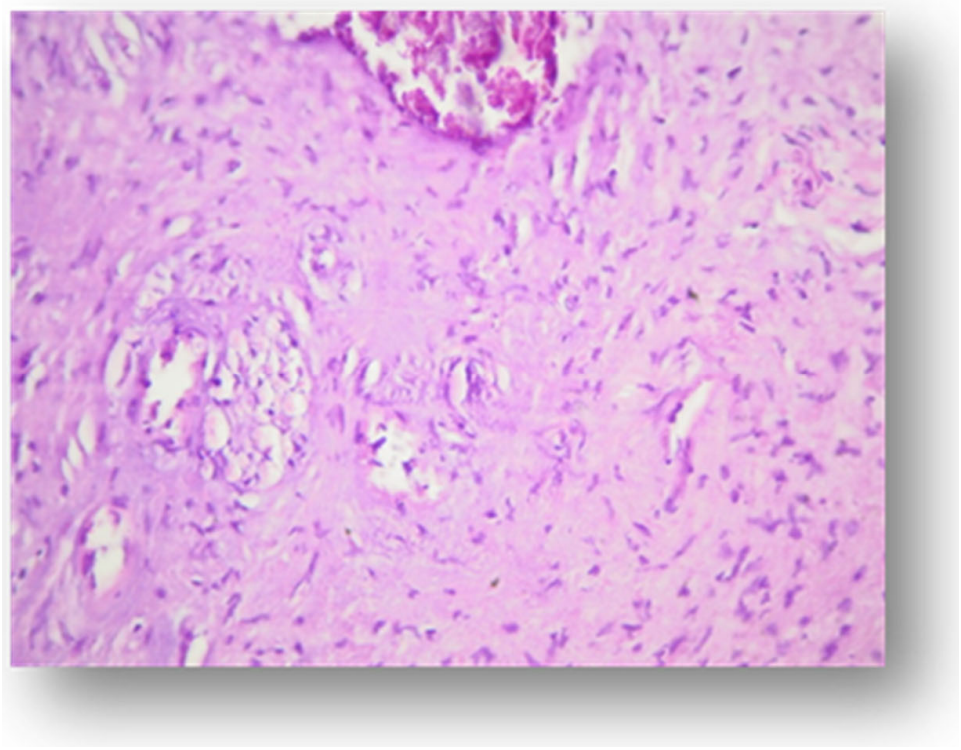

Figure 3. Coronal dental pulp aspect of a 47 year old female, type 2 diabetes HE staining, ×200.

Figure 4 shows the aspect of the dental pulp of a 49 year old patient, male with type II diabetes since 2008 and poor oral hygiene, with Hb 229 mg/ml and HbA1c 8.73%, suggesting poorly controlled diabetes at the moment of dental evaluation. There can be noted moderate inflammatory infiltrate with neutrophils and histiocytes, pupal sclerosis and irregular microcalcifications.

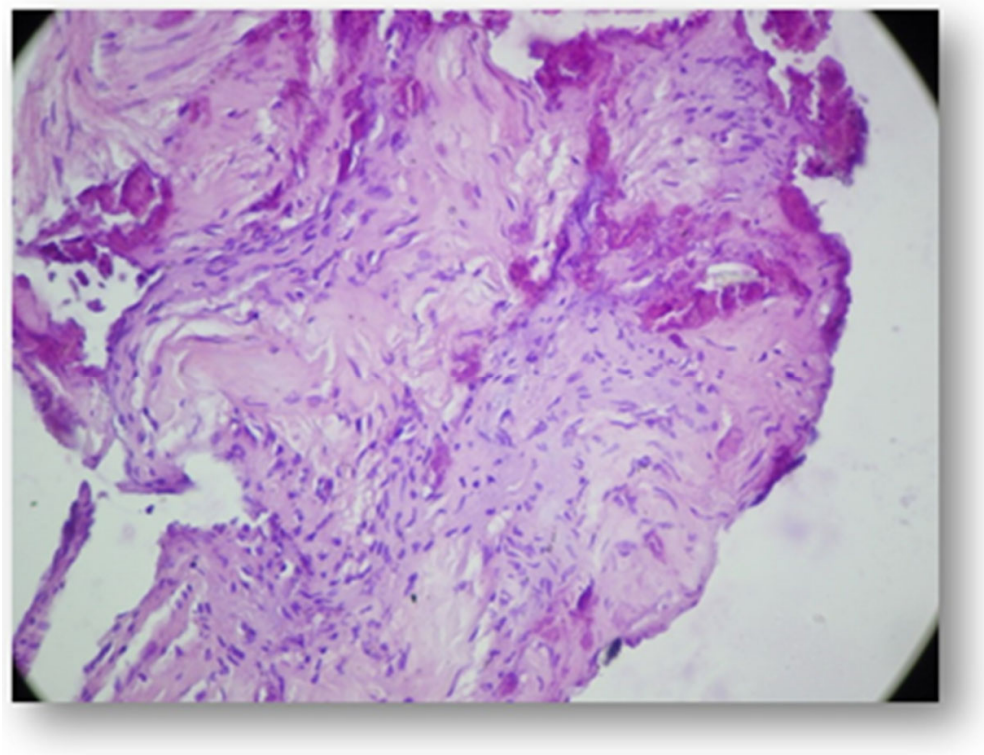

Figure 4. Dental pulp aspect (coronal pulp) of a 49 year old male, type 2 diabetes, HE staining, ×100.

Figure 5 illustrates the histologic aspect of the dental pulp of a female patient, 57 year old, with type II diabetes from 2006, Hb 296 mg/dl, HbA1c 11.82%, poor oral hygiene and many carious teeth. The histological aspect shows abundant diffuse acute inflammatory infiltrate and degenerated nervous fibers.

Figure 6 illustrates the histologic aspect of the dental pulp of a 57 year old female with uncontrolled type II diabetes from 2010, Hb 354 mg/dl and HbA1c 12.02%. The aspect of the dental pulp sections suggests diffuse inflammatory infiltrate, dilated vessels with thickened walls and neutrophils in their lumen. Diffuse pulp calcifications are also present, among small necrotic areas.

Figure 7 illustrates the dental pulp aspect of a 65 year old man with poorly controlled type 2 diabetes from 2005, having Hb 278 mg/dl and HbA1c 9.56%. The histological aspect shows important pulp sclerosis and irregular dystrophic calcification. Moreover, it can be noticed that there are abundant diffuse inflammatory infiltrate, a few eosinophils, plasma cells, lymphocytes and histiocytes.

Figure 8 shows the coronal histological aspect of the dental pulp of a 67 year old female with type 2 diabetes from 2007, having Hb 198 mg/dl and HbA1c 7.92%. The histological aspect shows acute inflammatory infiltrate, sclerosis and dystrophic calcifications.

Figure 9 shows the histological aspect of the dental pulp tissue of a 70 year old female with type II diabetes from 2001, Hb 212 mg/dl and HbA1c 9.46%. The pulp tissue shows marked sclerosis, areas with hyalinization and dystrophic calcifications. Few inflammatory elements are present. In the peripheric area, a few flattened odontoblastic cells are seen, together with a few fibroblasts and fibrocytes.

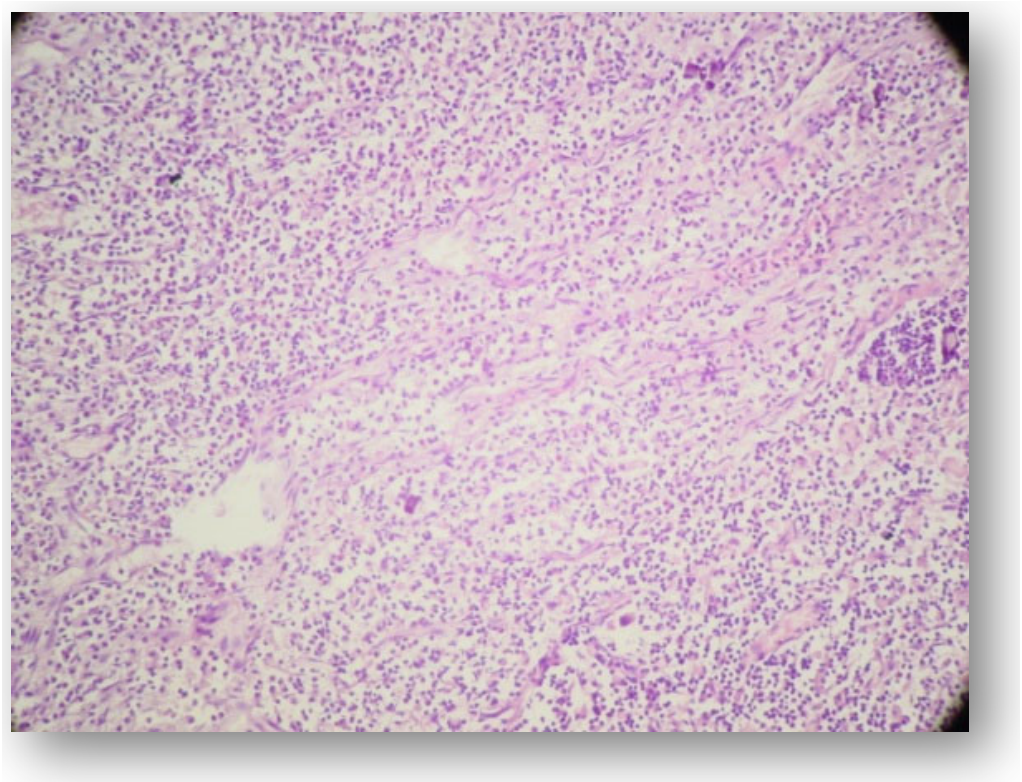

Figure 5. Dental pulp aspect (coronal pulp) of a 57 year old female, type 2 diabetes, HE staining, ×100.

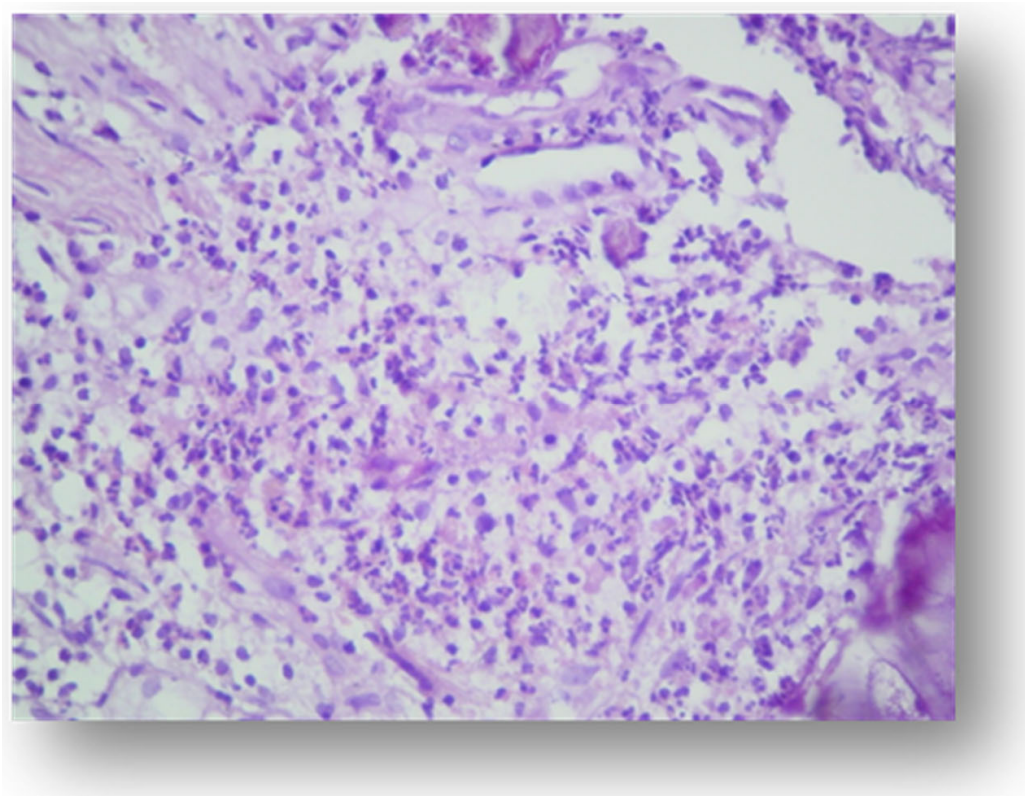

Figure 6. Dental pulp aspect (radicular section) of a 57 year old female, type 2 diabetes, HE staining, ×200.

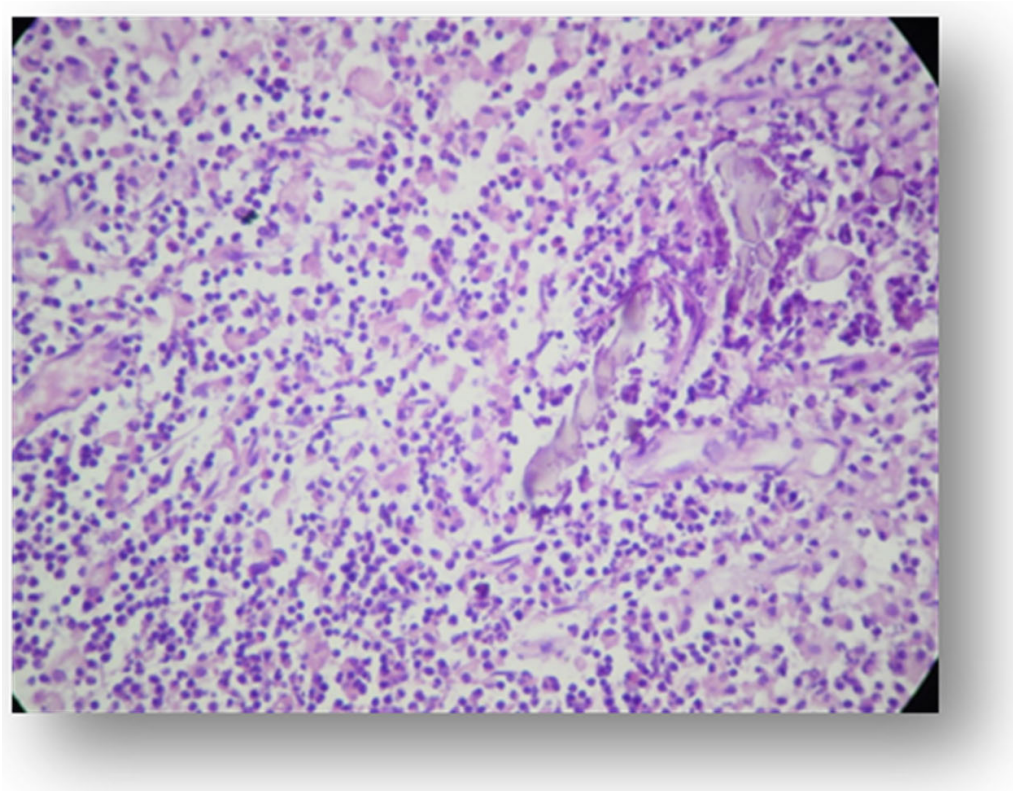

Figure 7. Coronal dental pulp aspect of a 65 year old man, type 2 diabetes HE staining, ×200.

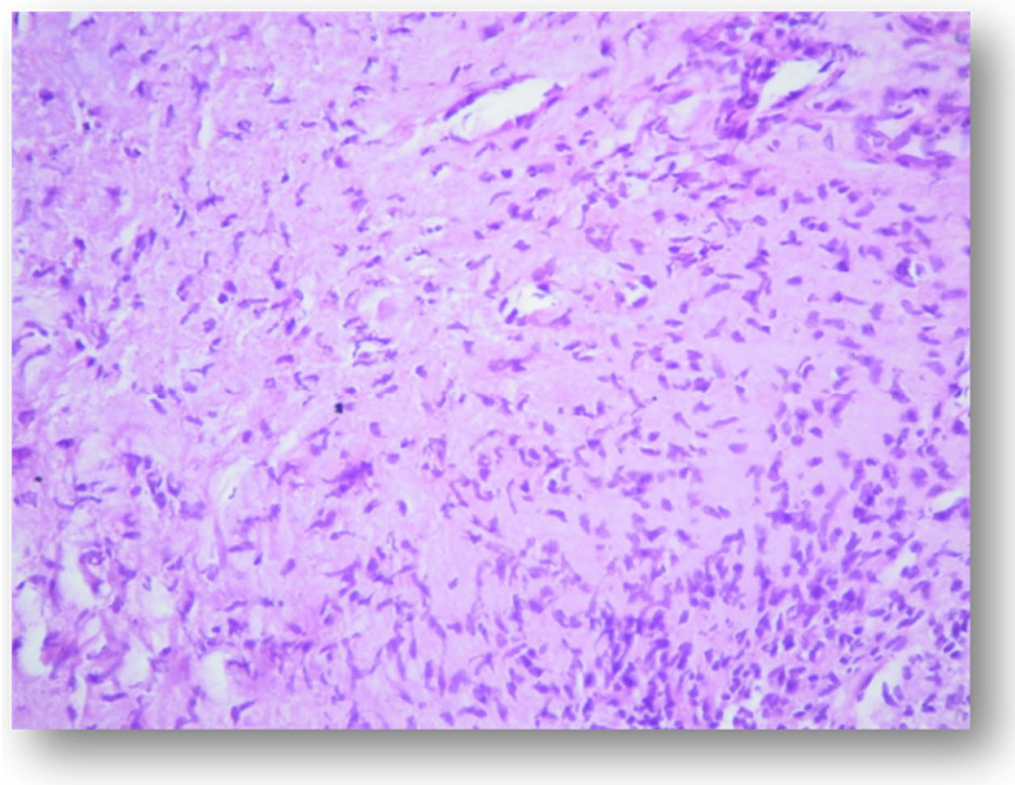

Figure 8. Coronal dental pulp aspect of a 67 year old female, type 2 diabetes, HE staining ×200.

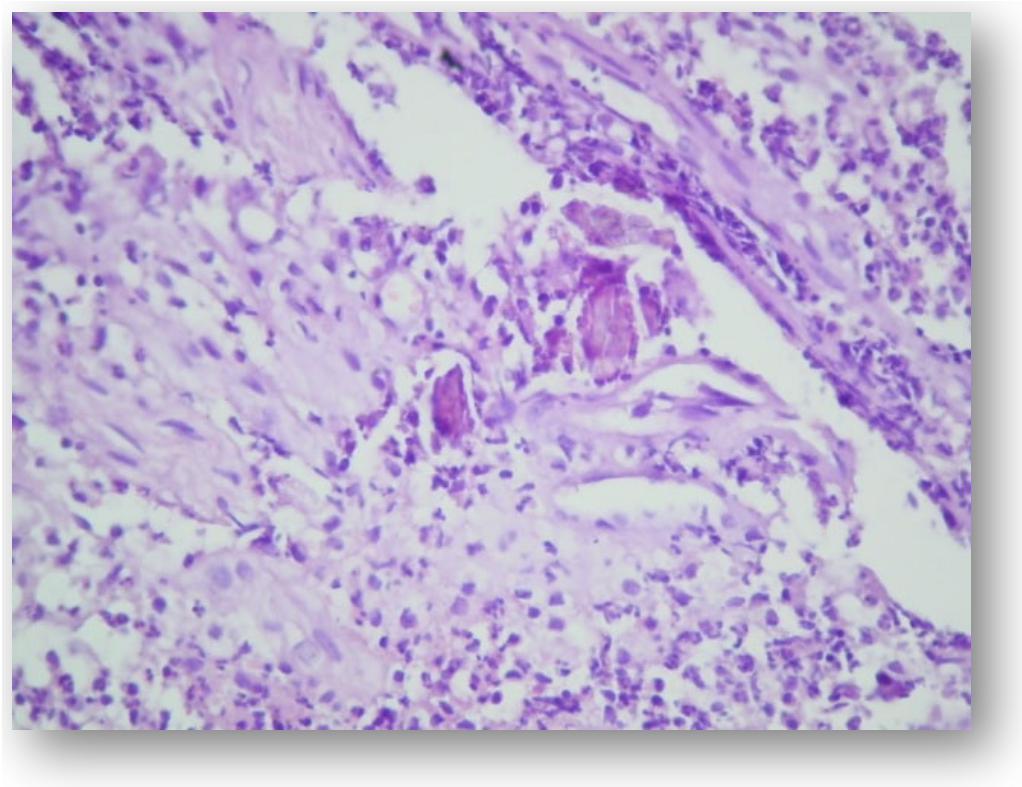

Figure 9. Radicular dental pulp tissue of a 70 year old female, type 2 diabetes HE staining, ×200.

Early aging aspects were noticed in younger patients (36–55 years old), from the study group (Figures 2–4), which could be the consequence of affected blood vessels and impaired pulp regeneration capacity.

In the 56–70 year old group, marked sclerosis and dystrophic calcifications, accompanied by inflammatory infiltrate were noticed (Figures 5–9).

The evaluation of the rest of the 15 pulp specimens revealed similar aspects: inflammatory infiltrate, degeneration of the nerves, thickened blood vessels walls and frequent calcifications. The chronic inflammation areas are proven by fibrosis and sclerosis, accompanied by discrete limfoplasmocitar infiltrate.

No statistically relevant correlation could be established between the level of glycemia and presence of inflammation (p = 0.14); also, no correlation was found between the level of glycemia and the presence of areas of necrosis (p = 0.23), or between the level of glycemia and the presence of pulp calcifications (p = 0.09). The time from diabetes onset could not be correlated with the presence of inflammation and necrosis, but positive correlation was found between the time from diabetes onset and the presence of pulp calcifications (p = 0.04).

4. Discussion

The influence of diabetes on dental structures has been previously studied, especially focusing on periodontal disease associated with diabetes [19]. The endodontic pathology associated with the diabetic condition in human subjects is more difficult to prove because dental pulp is not an exposed organ, as periodontal structures. Previous observations [20] suggest that the dental pulp of diabetic patients is in a state of inflammation because of nerve damage and local microcirculation breakdown, leading finally to pulp necrosis. The condition called "Diabetic odontalgia" was described in relation with longstanding hyperglycemia. It manifests as dental pain, which is easily confused with pulpitis, so uncontrolled diabetes might affect even the success of endodontic treatment [21], despite the fact that regenerative endodontics research has increased in popularity lately [22,23].

Contrary to other studies, in our study group, none of the teeth analyzed had clinical symptoms of pulpitis.

In the present study we aimed to assess the histological aspects of dental pulp specimens of vital carious teeth of patients with type 2 diabetes.

For the histological study, we used the Hematoxylin–Eosin (HE) stain. All pulp specimens had histological aspects of inflammation to a certain degree, with areas of fibrosis and fibro-sclerosis, accompanied with limfoplasmocitar infiltrate. Most of the specimens presented pulp calcifications, fibrosis and vascular changes, consisting of the thickening of the vascular wall by increasing its content in collagen, with most blood vessels presenting microscopic aspects of arteriosclerosis. Those observations suggest the fibrotic transformation of the pulp tissue, together with vascular changes, which could be consequences of hyperglycemia. It was shown previously that diabetic patients develop microangiopathy and arteriosclerosis [9], our study confirms those observations. The fibrotic changes in dental pulp, in some cases accompanied with areas of necrosis, can also be a consequence of ischemia, installed because of arteriosclerosis. Pulpal calcifications were also a characteristic of most of the specimens included in this study. The influence of the carious lesions in pulp stones formation could be linked to dentinal properties [24], in terms of the number and diameter of dentinal tubules on one side, and the rate of carious lesion progression on the other side [25–27]. The multiple diffuse calcifications can be a result of chronic hypoxia and cell death. Pulps of diabetics are more prone to such calcifications and have been linked to elevated hyperglycemia, duration of diabetes and diabetic vascular changes [13,14]. Other studies found that diabetic patients have pulp inflammatory lesions and even areas of pulp necrosis [9]. Recent, similar studies [27] showed that in the case of a diabetic patient, morphological changes in dental pulp can occur, depending on the status of the glycemic control of the patient and the time period from the onset of the diabetes. Structural changes observed include inflammation with the presence of calcifications, frequently sickle-shaped [28,29], or even necrosis. Similar histological aspects were observed among the pulp specimens included in this study, but no correlation could be established between the level of the glycemia or the time period from the diagnosis of diabetes and pulp structural changes, probably because of the relatively small number of pulp specimens analyzed. The presence of pulp calcifications seems to be associated with the duration of diabetes. Other associated systemic conditions could also influence the dental pulp histologic aspects, but patients were selected among those who did not report other known systemic diseases during anamnesis. One limitation to this study is the relative low number of patients included in the study, with a large age group interval (36–70 years old). Another limitation of the study was the possible influence of other systemic pathologies, which were not reported by the patients. Additionally, all patients included in the study had poorly controlled diabetes. It is important to assess also the status of the dental pulp of patients with an adequate glycemic control, but we could not identify and include such cases in the study. The dental pulp of type 2 diabetic patients, with its various pathological aspects, could constitute an additional challenge for dental treatment, so clinicians must understand the disease and its consequences for the pulp tissue, especially if dealing with patients with poor glycemic control.

5. Conclusions

The analyzed dental pulp specimens of carious teeth of type 2 diabetic patients have shown fibrotic transformation of the dental pulp, with the presence of calcifications, arteriosclerosis and inflammatory infiltrate. In this situation, the attitude of the dentist in pulp vitality preservation for the carious teeth of diabetic patients should be limited. Those limits are given by the impaired capacity of the dental pulp to maintain its proper functionality, a situation which could complicate the dental pathology.

Author Contributions: Conceptualization, C.G.P. and C.L.Ș.; methodology, C.G.P. and R.A.P.; software, L.C.P.; validation, E.D. and L.S.; formal analysis, E.D. and M.G.; investigation, R.M.M.; resources, R.A.P. and L.C.P.; data curation, C.G.P.; writing, C.G.P. and R.A.P.; visualization, E.D. and L.S.; supervision, L.S. and C.L.Ș. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of "Ovidius" University of Constanta, Romania (10788/30.08.2020).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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