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Study on the histopathological modifications of the dental pulp in occlusal trauma

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Abstract

The diagnosis of occlusion-generated disorders of the dento-maxillary apparatus represents a sensitive stage within the establishment of the therapeutic means for the functional rehabilitation of dental arches. The laborious effort carried out in order to specify the diagnosis resides in the fact that any trauma arising at the level of any component of the stomatognate system may lead to an occlusal dysfunction. The uncured carious processes, besides the pulp and periapical complications, may lead to an occlusal dysfunction through horizontal migrations of teeth resulting in the derangement of the occlusal curvatures as well as through vertical migrations of the teeth opposing a tooth diagnosed with occlusal caries or which largely reduced the coronary height. The dental iatrogenia, besides the eructation anomalies and neuromuscular dysfunction within the oromaxillofacial area also determines the appearance of occlusal dysfunction. The radiological examination through correlation with the clinical manifestations may provide significant data related to the magnitude of the prejudice caused to dento-paradontal units experiencing occlusal trauma. The histopathological study through correlation with the clinical manifestations provides significant data on the tolerance of dento-paradontal units within the occlusal dysfunction. Also, subsequent to the analysis of the possible actions of aggression generated by the occlusal trauma correlations could be determined between the type of the histological lesion of the pulp-dentine complex and the etiopathogenic factors, as well as correlations depending on the damage degree through occlusal trauma of the dental parts involved.

Keywords: occlusal trauma, pulp-dentine complex, demineralization.

Introduction

The modifications resulted at the level of dento-parodontal units could result subsequent to the modification of the direction of forces operating on them; it is therefore proved that any change of their direction could determine the appearance of the occlusal trauma phenomenon characterized by specific clinical signs.

On the assumption that any occlusal force acting on a tooth, besides those distributed on the vertical axis, could determine modifications of the local biology, or it may influences the local physiology through "waves" transmitted towards other dental units, with negative consequences on the dento-maxillary apparatus, subjective and objective clinical signs were revealed which may be classified as characteristic signs for the occlusal trauma phenomenon.

The occlusal trauma by means of triggers may lead to changes in pulp and dentinal tissues. A multitude of internal or external factors could act on the dental pulp, either indirectly through strong tissues surrounding the pulp, or directly in the case of pulp chamber opening. The pulp tissue succeeds sometimes to protect itself resulting in a remission of the phenomena finally restoring the normal state (*restitutio ad integrum*) or it undergoes a series of pathological transformations. The reaction of the dental pulp to the action of different rousing factors is generally similar to the reaction of other conjunctive tissues within the body but, nevertheless, some particularities arise due to the conditions under which the dental pulp is located.

The pathological modifications are determined by the intensity and duration of the action exercised by the irritable factors (occlusal trauma) and also by the reaction capacity of each separate body. As the modifications perceived at this level are many times similar with those revealed within the orodental pathology, the present study attempts to find another approach which could define the concept of occlusal trauma in terms of results achieved and to assess the impact on the pulp-dentine complex on the basis of records regarding the existence of the respective phenomenon attested through clinical and paraclinical examination.

Materials and Methods

The study was carried out on a group of 30 patients during the period 2009–2010. In order to be able to achieve a comparison between the results obtained and to reduce the interpretation errors a separate assessment

was considered depending on gender and age and finally the summing up of the results obtained should be conducted.

The method of study consisted in the tracing of all dento-parodontal clinical lesions, their location and stipulation of the type, associated or not during the first stage concerned with the establishment of the diagnosis of dysfunction. The carrying out of the study took into account the presence or the absence of the gnato-prosthetic devices. The analysis of the occlusion reports in statics and dynamics permitted the approach of the extraoral analysis of the dento-dental reports. The completion of data collected by clinical examination required a radiological examination in order to establish the diagnosis of dysfunction due to occlusal trauma.

The radiological examination was performed on groups of teeth, the frontal and lateral teeth respectively, comprising both the maxillary and the mandibular area. The method of study consisted in the radiological investigation by means of the bisector technique (Dieck).

The histopathological study used dental pulps as reference material sampled from a number of 45 teeth, both monoradicular and pluriradicular. The study of the dental pulp could be carried out subsequent to: vital ablation (20 teeth), fracturing of teeth followed by the sampling of pulps subsequent to the removal of osseous fragments (15 teeth), decalcification of teeth (10 teeth), followed by their processing through the histological technique of paraffin inclusion. The sections obtained were colored by means of Hematoxylin and Eosin staining and Goldner–Szekely trichromic. In order to report the histological aspects to the normal structure of the dental pulp a number of five formulations comprising normal dental pulps were used for that matter.

Results

The assessment and diagnosis of disorders generated by occlusal events has been carried out according to a phasing-in approach so as to allow, by the summing of data obtained, the surgical procedures for the sampling of dental pulps and for the obtaining of histopathological preparations. The association of data constituted the final stage of the respective study and permitted, at the same time, the assessment of the occlusal trauma phenomenon and the impact on the pulp–dentine complex.

The clinical examination reveals, subsequent to investigations carried out, the fact that coronary destructions, dental fractions, edentation without prosthetics supplemented by conjunct temporary or long-lasting prosthetic works which do not reinstate the occlusal stops in the vertical, cross-cutting and sagittal plane determine disorders of the occlusal reports. Any modification resulted at the level of arches, including dental anomalies, could generate forces, which might turn into irritating spines, due to the manner they are directed, both for the dental structures and for the paradontium (Figure 1).

The iatrogenic occlusal trauma leads to the developing of milolisis lesions of which depth decreases as the tooth topography stands away from the place of the occlusal trauma. We ascertained that the milolisis lesions are associated with gingival retractions. This fact can give rise to the occurrence of some retentive cervical dental areas, which favors the generation of cervical caries inside cementum (Figures 2 and 3).

For patients with inserted edentations without prosthetics but having the residual teeth support paradontium resistant to occlusal overstress one may notice the presence of dental abrasion. The most frequently encountered topography of abrasion facets is revealed at the level of frontal residual teeth. At the level of the maxillary frontal group, the abrasion facets are oriented from the vestibular area towards the palatine area; the surfaces of the frontal mandibular teeth have abrasion facets orientated from the lingual area towards the vestibular area (Figure 4).

The presence of edentation without prosthetics indicates gingival retraction both for the jaw and the mandible especially at the level of teeth bordering the edentated breach as well as oral-vestibular mobility supplemented by the presence of the egression and extrusion phenomena followed by the penetration of the occlusal plane, accentuated depending on the age of the edentation and on the mastication stereotype (Figure 5).

This situation covers the presence of vicious habits and bruxism, as determinant factors, but the awareness of the occlusal trauma and its symptoms proves that the occlusal rebalancing through prosthetic constructions may amend clinical phenomena (Figure 6).

The clinical examination carried out in this respect may not reveal so many indices and the radiological inspection should supplement data collection in the diagnosis of dysfunction due to occlusal trauma.

In terms of radiological inspection, one may notice the existence of some minor osseous lesions of various types: the limited resorption of the osseous interalveolar septum revealing an amputated-like shape or the halisteresis resorption in the central part of the osseous interalveolar septum with hypercondensation of the internal alveolar smear (Figure 7).

At the level of lower frontal incisors, it can be noted that the accentuated ablation of the interdental septa accompanied by a decrease in volume of the pulp chamber or the presence of a “sink-like” alveolar resorption, both on the horizontal and vertical planes (Figures 8 and 9).

Dental tissues subject to occlusal traumatic events undergo a process of hypercalcification and therefore the pulp chamber might appear much more reduced due to residues of secondary dentine and sometimes the occurrence of pulpolytes is noticed (Figure 10).

During repeated occlusal injuries, a decrease in dimension of the pulp chamber is induced from the occlusal towards the apical plane displaying a rectilinear aspect of the pulp chamber occlusal wall. Thus, inversions of the crown-root report may be noticed horizontally and vertically as well as milolisis lesions – an indisputable sign that the respective tooth undergoes occlusal trauma (Figure 11).

The pathological modifications revealed subsequent to the histological inspection arise depending on the intensity and duration of irritating factors (occlusal

trauma) but also on the reaction capacity of each separate body.

The present study showed, besides the residues of dentine at the pulp's outer edge, under the form of primary, secondary or reactive dentine, some mineral depositions inside the pulp (free, inside the coronary or radicular pulp; inserted depositions (included in the dentine); attached depositions (partially inserted in the dentine). Diffuse mineralization processes are disclosed emerging as "sand" on smaller or more extended areas. These depositions are noticed on some vessel or nerve wall following the length of a conjunctive fiber, at the level of a group of degraded cells which attract mineral salts by their alkalinity (Figures 12 and 13).

Figure 1 – ***Dysfunction by agenesis of maxillary lateral incisors.***

Figure 2 – ***Milolisis lesions associated with junction caries.***

Figure 3 – ***Milolisis lesions encountered at the upper frontal group.***

Figure 4 – ***Generalized abrasion through edentation and its consequences.***

Figure 5 – ***Subsided occlusal plane.***

Figure 6 – ***Abrasion of maxillary central incisors subsequent to vicious habits.***

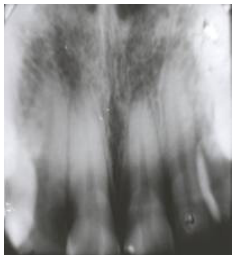

Figure 7 – ***Hypercondensation of the internal alveolar smear 1.1/1.2.***

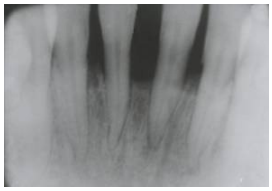

Figure 8 – ***Horizontal and vertical resorption of the alveolar bone.***

Figure 9 – ***"Sink-like" alveolar resorption.***

Figure 10 – ***Pulpolyte (pulp chamber 3.6).***

Figure 11 – ***Radiological image of the milolisis lesions.***

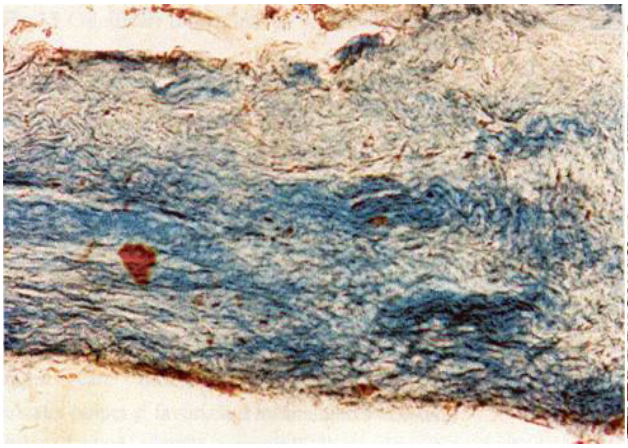

Figure 12 – ***Atrophic pulp with marked proliferation of collagen fibers (Trichromic stain GS, ×200).***

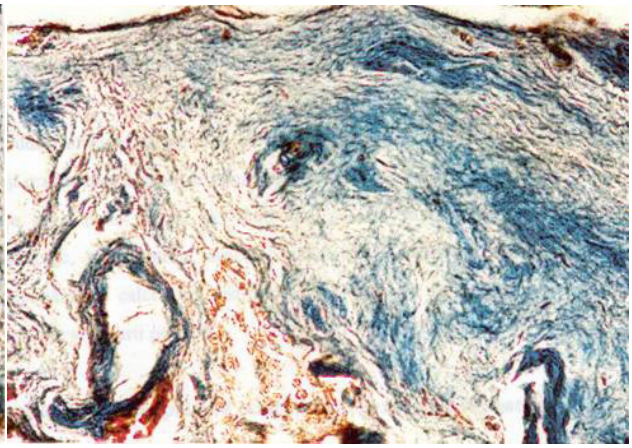

Figure 13 – ***Diffuse calcifications within a pulp atrophic tissue (Trichromic stain GS, ×400).***

The study carried out permit a correlation between the clinical symptoms and results obtained subsequent to histopathological examinations of tissues.

A number of 39 teeth among the 45 investigated teeth by means of histopathological inspection revealed different histopathological signs ranging from pulp dystrophies up to dystrophic calcifications, which denote important pathological modifications of the pulp structure (Table 1).

Table 1 – ***The injury degree of the pulp revealed through histopathological examination***

No. of teeth studied	Normal pulp	Pulp dystrophies	Calcification
45	6	24	15
%	14.3	53.3	33.3

As regards the six inconsistent cases, although from a clinical point of view there were signs of pulp suffering, the structure of the pulp has not been affected. This remark proves that the dental pulp has a good protection capacity as long as the sanguine input at the level of apical foramen is not modified, the germs from the paradontium did not invade the apical foramen, the collateral canaliculi, the dentinal tubules and in cases when the tooth is recovered from an occlusal point of view.

The analysis of the correspondence between the clinical and the histopathological diagnosis indicates a confirmation for 86.6% of the cases, a number that assigns high importance to the histopathological examination for the determination of the diagnosis and the therapeutic behavior to be adopted.

Discussion

Within the studies carried out in relation with the occlusal function and dysfunction, Ash M and Ramfjord S [1] show that real cuneiform lesions (milolisis) are lacking in carious dentin, as they are located directly inside the enamel. These lesions are deemed as patognomonic by many authors for teeth under occlusal trauma [2–4].

These lesions deprived of dental strong tissues are located on the vestibular side within the junction area and are shaped as an obtuse angle in section opened towards the buccal vestibule, crossing the strong coronary tissues but also extending to the radicular cementum at the same time with the retraction of the marginal paradontium [5, 6]. The walls of the cuneiform injury are slightly modified in color and have a firm consistency, the thermal or chemical sensitivity is inconsistent and the evolution of the lesion is pending [7]. The iatrogenic occlusal trauma results in the occurrence of milolisis lesions at the level of teeth located on the dental arch accommodating the prosthesis. It can be noted that the depth of these lesions decreases as the tooth topography stands away from the place of the occlusal trauma [8]. We ascertained that the milolisis lesions are associated with gingival retractions. This fact can give rise to the occurrence of some retentive cervical dental areas, which favors the generation of cervical caries inside cementum. Therefore, three clinical manifestations could be associated to the occlusal trauma: the milolisis lesion, the gingival retraction, the cementum caries, which was also attested by the researches of Svanberg GK *et al.* [9].

For patients with inserted edentations without prosthetics but having the residual teeth support paradontium resistant to occlusal overstress we noticed the presence of dental abrasion with specific orientation for the maxillary and mandibular teeth, which was attested by the researches of Le Gall MG and Lauret JF [10]. Nunn ME and Harrel SK [11] demonstrates that dentinary hyperesthesia or pulp affections are generated subsequent to the abrasion produced through occlusal interference, parafunctions, exposure of the dentine, opening of the pulp chamber in certain cases, beginning with hyperemia and also mentioning the pulp necrosis. The occlusal obstacles and/or parafunctions supplemented by the abrasive capacity of materials for prosthetic reinstatement often determine the occurrence of pathological abrasion [11–13]. The reduction of the masticatory field by edentation also accelerates the abrasion [14–20]. The overturning and the axis rotation of dental parts, encountered more often at the monoradicular level contribute, by their positioning, to the emphasis of harmful forces directed horizontally which triggers and maintains the occlusal trauma phenomenon [21, 22].

The periodontal pain is due to the periodontal traumatic processes through occlusal overstressing. It might arise either after exceeding the painful threshold of periodontal receptors subsequent the occurrence of an intense occlusal traumatic event or after repeated strains of the supporting tissues [22]. Against the background of a deficient periodontal structure, the dental pathological migration aggravates the existing traumatic occlusion bringing forward a more accentuated effect used for the paraxial transmission of masticatory forces so harmful for the entire dento-maxillary apparatus. Devital teeth which have no lesion capable to generate the pulp necrosis should be suspected for having endured abnormal occlusal loads which determined disorders of the pulp nutrition leading to its final necrosis [23, 24].

Actually, all the occurrences referred above influence the capacity to cope with occlusal trauma; consequently, a normal stress appears as supra-threshold emphasizing the traumatic character of the occlusal forces [25, 26].

By supplementing data to the clinical examination, we noticed during the radiological inspection the existence of some minor osseous lesions of various types: the limited resorption of the osseous interalveolar septum revealing an amputated-like shape or the halisteresis resorption in the central part of the osseous interalveolar septum with hypercondensation of the internal alveolar smear, a decrease in volume of the pulp chamber as well as “sink-like” alveolar resorptions.

A process of hypercalcification can be noticed and therefore the pulp chamber might appear much more reduced due to residues of secondary dentine. The calcareous opacity does not continue the walls of the

pulp chamber as a radio-transparent gingival line exists more often than not between the pulpolyte and the dentine wall. As opposed to the pulpolyte the calcific process in diffuse sclerosis is propagated on the entire pulp area. The radiological aspect is represented by the granular calcareous aspect of the coronary and radicular pulp [27–30]. We noticed a heterogeneous calcification which comprises the entire pulp but, according to the radiological image, the opacity is more intense at the level of the pulp chamber due to the thicker calcareous layer crossed by radiations as specified by the researches of Calandriello M *et al.* [8, 29]. The reaction dentine reduces the volume of the pulp chamber or of the radicular channel at a specified location; the contraction arises around the maximum intensity of the action generated by the harmful factor.

During repeated occlusal injuries, a decrease in dimension of the pulp chamber is induced from the occlusal towards the apical plane displaying a rectilinear aspect of the pulp chamber occlusal wall [31, 32].

The reaction of the dental pulp to the action of different rousing factors is generally similar to the reaction of other conjunctive tissues within the body but, nevertheless, some particularities arise due to the conditions under which the dental pulp is located. Nevertheless, the specialized literature mentions the role of some risk enhancing factors, such as some general diseases, which would loosen the reactivity power of the pulp tissue thus influencing the site where pathological processes will be carried out [33–35].

Avery JK [36], Bender IB [37], Bhaskar SN [38] demonstrated that the dental pulp reacts to the action of some harmful stimuli, including the occlusal trauma, by the mobilization of a large number of protection cells represented by macrophages, lymphocytes, polymorphonuclear cells triggering inflammatory and immunological reactions as well as the development of new dentine layers.

The triggering factors of the occlusal trauma may generate a protection response induced by the dental pulp under the form of elaborating the reactive or tertiary dentine [39–41]. The secondary dentine presents a smaller number of dentinal tubules and a poorer mineralization. The tertiary dentine is characterized by the absence of dentinal tubules almost entirely and where some are found they are anarchically oriented. As regards the mineralization, it is poorer than noticed for the secondary dentine when the trauma is acute and therefore, only mineralization islands could be detected within the organic mass or it is intensely mineralized when the trauma operates slowly and for a long period of time [8, 41, 42].

The tertiary dentine is produced throughout a surface limited to the stirring factor's reach limit as opposed to the secondary dentine which precipitates gradually, in time, on the pulp's interface, but in certain areas it seems more projecting. The reparatory dentine, due to the absence of dental tubules and of odontoblastic elongations as a result is less sensitive [35, 43].

A boundary calcium traumatic line is noticed between the primary or secondary dentine and the tertiary dentine. Holland GR [43], Garant PR and Cho MI [44] observe that the pulp chamber decreases in volume subsequent to this dentine deposition, which is also revealed by the radiological inspection. This determined a crowded odontoblastic layer and the circulation's disorders induced by the decrease of sanguine flow due to the depositions of secondary dentine at the apical level results in degeneration processes of odontoblast-like cells, followed by the alteration of their function and further replacement with lacunar spaces or the occurrence of greasy involutions.

The present study also revealed some diffuse mineralization processes, emerging as "sand", on smaller or more extended areas. These depositions are noticed on some vessel or nerve wall following the length of a conjunctive fiber, at the level of a group of degraded cells, which attract mineral salts by their alkalinity. These diffuse calcifications are determined by the precipitation of the calcium orthophosphate crystals along the vascular walls or by the deposition of hydroxyapatite crystals along the collagen fibers. The fibrosis process and the calcifications indicate a regression of the pulp tissue; microscopically they appear as astructured, confluated zones, developing various dimensions. The cases examined indicated that these depositions might be related both to the ageing of the pulp and to some chronic inflammation processes.

The larger denticles are less in number and they gather around the radicular pulp especially, diversely oriented and revealing a poorer mineralization [41, 45]. Ciftcioglu N *et al.* [46] describes these formations as constituted from mineralized conjunctive tissue first emerging as small mineralization nuclei and further gradually developing by the deposition of new layers exhibiting a lamella-like structure. Vataman M *et al.* [35] believe that the term of "denticle" should refer only to deposits formed by dentine and the term of "pulpolytes" should refer to mineralizations without well-defined structures. The pulpolytes are generated from degraded cells, which constitute the nucleus on which mineral salts are concentrically deposited.

These particular views lead to the conclusion that a pulpolyte invading the entire volume of the pulp chamber is not always generated by a single mineralization point, but it might be formed by the conjunction of smaller formations which further turn into a mineralized mass, larger in volume. The major part of the pulpolytes were discovered at the level of molars apparently due to the pulp chamber volume which permitted their development and to their easily localization during the radiological inspection.

Conclusions

The paraxial transmission of the forces of mastication represents a significant factor for the occurrence and emphasis of the occlusal trauma phenomenon.

Marginal parodontopathies with bivalent etiology, occlusal and microbial, clinically manifest by signs of inflammation, but they are also accompanied by lesions of the ligamentous fibers and of the alveolar osseous structures.

Structural modifications result at the pulp level

represented by inflammation, fibrosation, calcic involutions.

Calcareous involutions do not appear as a dystrophic freestanding lesion but subsequent to some complex dystrophic-atrophic manifestations of elements forming the pulp conjunctive tissue and finally indicate the result of some local and general metabolic pains.

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