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## Calcific metamorphosis of the pulp is not pulp calcification

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**Abstract:** Dysplastic dentin deposited in pulp spaces by cells transformed into odontoblasts to survive a concussion-type dental trauma should not be called calcification or pulp mineralization, but metaplasia or calcific metamorphosis of the pulp. Fibrosing and pulpal hyalinization, followed by the deposition

of minerals on hyalinized collagen areas in fibrous pulps, are part of early pulp aging caused by the inappropriate use of the teeth, such as in the severe attrition, abrasion, caries and restorations - without any relation to the age of the individual - and should be called pulp nodules and diffuse calcifications

of the pulp. Pulp calcifications and calcific metamorphosis of the pulp are different processes and diseases between them as to the causes, clinical pictures and clinical conducts to be adopted. **Keywords:** Calcific metamorphosis of the pulp. Pulp nodules. Diffuse pulp calcifications. Calcifications of pulp.

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## INTRODUCTION

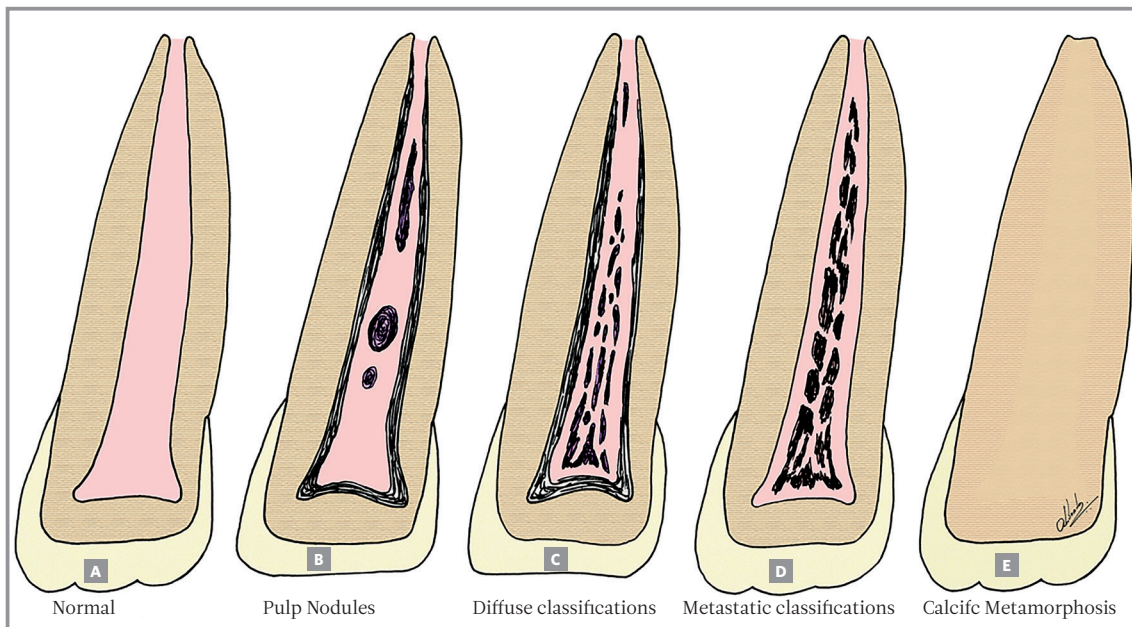
The names of diseases must be accurate because, when mistaken, they can generate inadequate diagnoses and treatments, with damages to the patients. Often, we do not care about these details, but they may represent different and distinct phenomena, including pulp changes<sup>1</sup>. What pulp calcification or mineralization means and how it occurs is totally different from what metaplasia or calcific metamorphosis of the pulp represents<sup>1</sup> (Fig 1).

## MINERALIZATION AND CALCIFICATION: SAME OR DIFFERENT TERMS?

Calcifications, to be precise, represent the deposition of calcium ions on a normal or ab-

normal organic matrix; they may be areas of necrosis free of bacteria or areas of biochemical modification of the extracellular matrix of soft tissues, as it occurs in some cutaneous diseases, walls of blood vessels and also in aged pulps.

Mineralization is a broader term and represents the deposition of various minerals on a normal or abnormal organic matrix, including even calcium, but with many other mineral elements. A process in which only the deposition of calcium salts occurs is very rare, or virtually nonexistent in the body. Generally, their deposition occurs along with that of other ions, such as phosphorus, for example.



**Figure 1:** Imaging comparison among the three types of calcification/pathological mineralization of the pulp (in B, C and D) and metaplasia or calcific metamorphosis of the pulp in E. In A, it is observed a normality scheme of the pulp space. In B and C, the cause is abrasion in the incisal, with reactive secondary dentin deposition reducing pulp volume (arrows). As part of pulp aging, there are pulp nodules in B; in C, diffuse calcifications of the pulp. In D, there are metastatic calcifications that are not related to aging, but to hypercalcemias. In E, in the metaplasia or calcific metamorphosis of the pulp, the absence of pulp boundaries due to its erasure has no relation to pulp aging, but rather to a reaction of dental concussion.

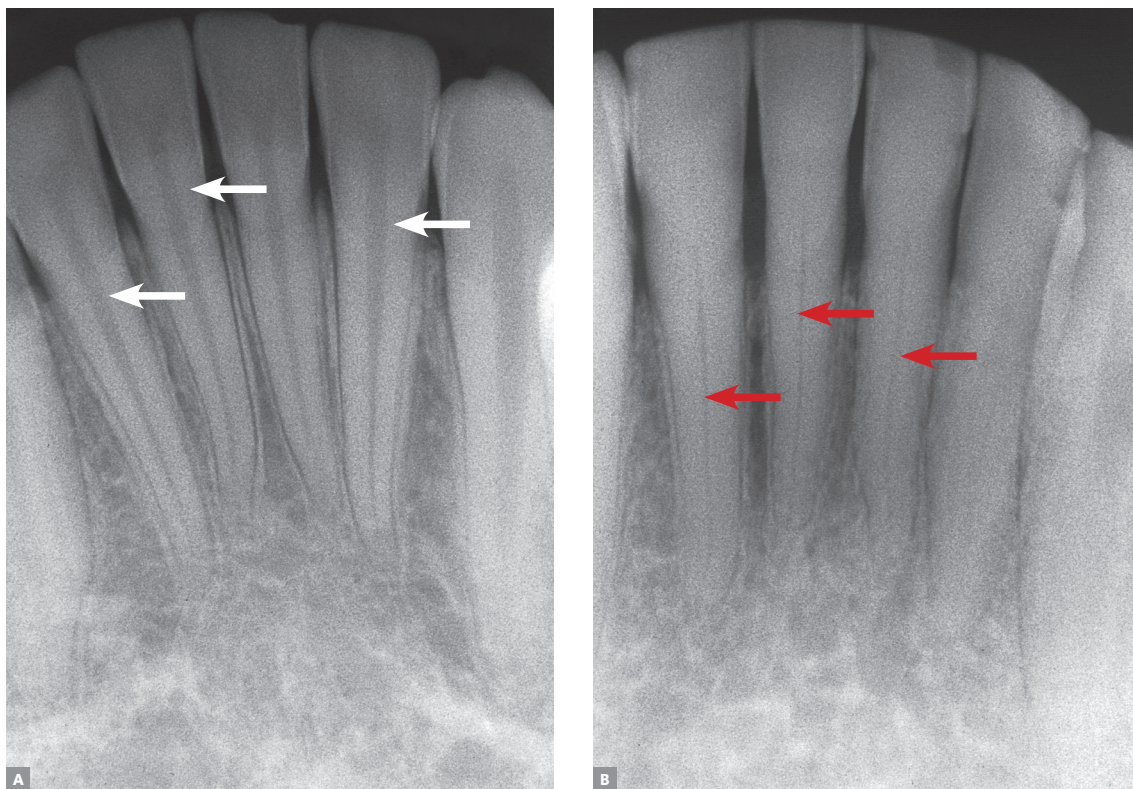
To the processes of pathological mineralization that occur in the body, it is more precise to refer as mineralization (it refers to several minerals, as it occurs in these cases) than as calcification (which refers exclusively to the calcium ion, which almost never acts alone in these processes). The point is not about being right or wrong, but rather about terminological precision: mineralization would be more accurate or appropriate.

**METAPLASIA OR METAMORPHOSIS:  
A TRANSFORMATION OF THE  
CELLULAR BIOTYPE**

Metaplasia or cellular metamorphosis in our tissues represents a change in the morphologi-

cal aspect of a mature cell, transforming it into an equally mature one, such as a fibroblast into an odontoblast. Metaplasia occurs much in the epithelium of the mucosa of the trachea in smokers: the ciliated cylindrical pseudostratified epithelium becomes parakeratinized stratified squamous epithelium to adapt to this slow and steady aggression represented by tobacco. Metaplasia, or metamorphosis, has the same meaning when applied to tissues.

In the still alive traumatized pulp, metaplasia or metamorphosis causes almost all cells to turn into odontoblasts, which then initiate the deposition of a malformed dentin, which may be called dysplastic dentin. It is poorly deposit-



**Figure 2:** Example of early pulp aging. In **A**, the pulp spaces were preserved in their dimensions. In **B**, early pulp aging induced by causes such as attrition, abrasion, caries and restorations narrowed the pulp spaces by sharp deposition of reactive secondary dentin, but maintained the pulp boundaries.

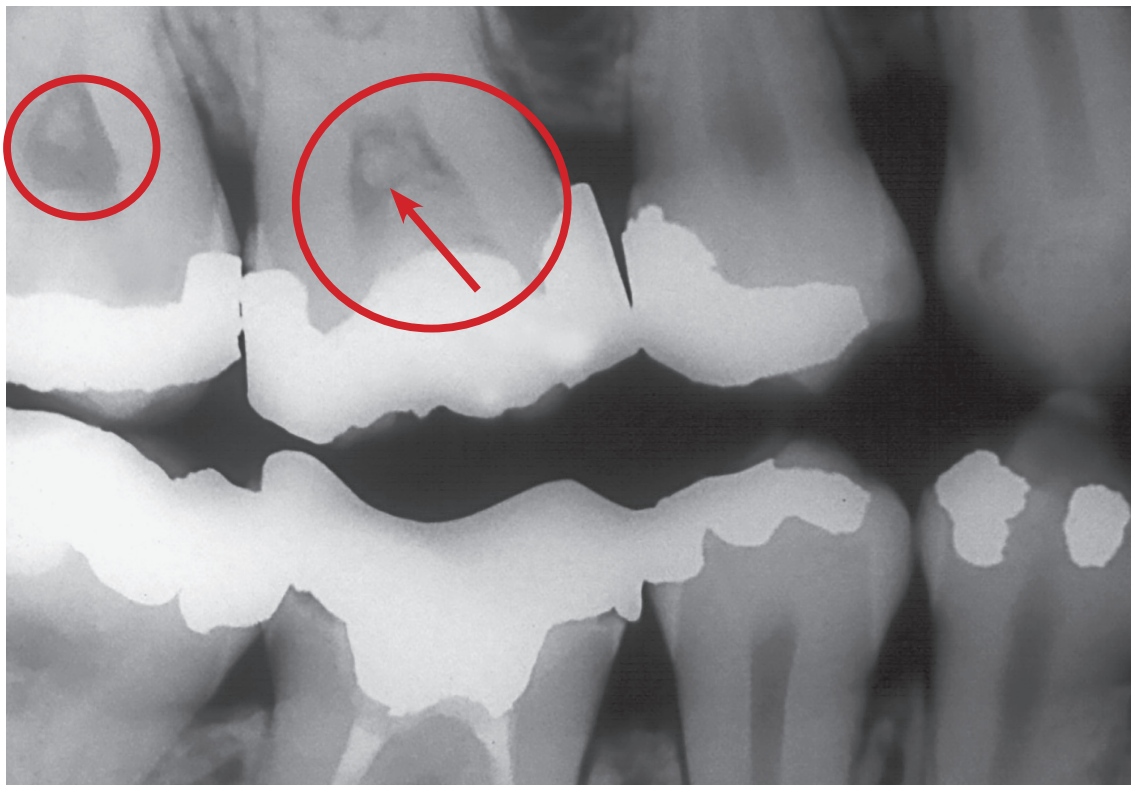
ed, but it fills the pulp spaces and replaces the soft tissue with a disorganized dentin, even in its mineralization process. Gradually, the pulp space fades and its limits disappear, leaving the radiographic image as a radiopaque fog (Fig 1), while the tomography shows a closed pulp space.

**WHAT ARE CALCIFICATIONS AND/OR PULP MINERALIZATIONS?**

Pathological calcifications or mineralizations of the dental pulp are:

**1 - PULP NODULES**

In the radiolucent pulp space, pulp nodules appear as radiopaque dots, which represent calcifications or mineralizations in hyalinized areas of the pulp, resulting from an exuberant pulp fibrosis due to early aging of the pulp, generally induced by factors such as attrition, abrasion, caries and restorations (Fig 1, 2, 3). This process may also occur in the vascular and neural walls, forming linear, narrow and long nodules, more common in premolars (Fig 4).



**Figure 3:** Pulp nodules represent the most striking imaging manifestation of early pulpal aging (circles and arrow). They are presented as irregular focal radiopaque areas within the pulp space from the mineralization of hyalinization areas of the extracellular matrix of the specialized pulp connective tissue. Pulp boundaries are maintained and visualized.

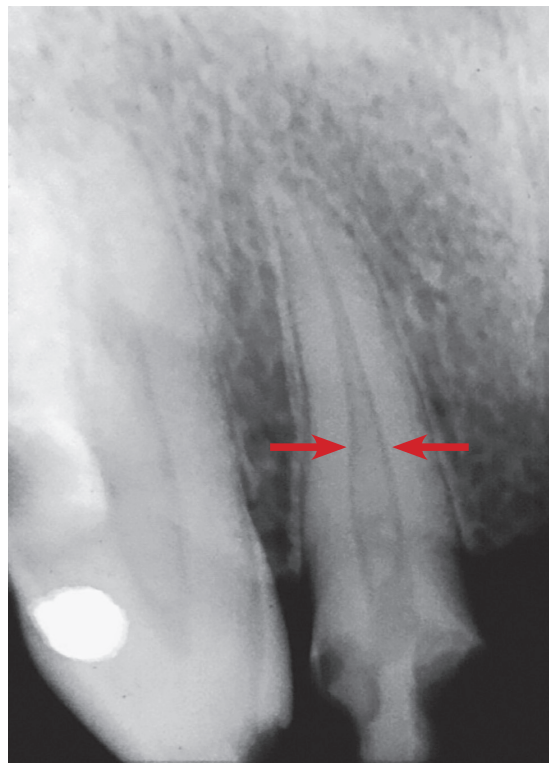




**Figure 4:** Pulp nodules may present in a linear or elongated form, especially when their origin is due to deposits of minerals in hyaline areas on the walls of vessels and or nerves. The maintenance of clear and visible pulp limits (arrow) is highlighted.

The pulp boundaries, when the nodules are present, are preserved, clear and visualized on radiographs and tomographies (Fig 1 to 4). Pulp nodules represent the early aging of the pulp, and are not consequences of dental trauma.

Pulp nodules are not associated with pain, do not compress vessels and nerves, do not promote pulpitis or pulp necrosis. For the en-

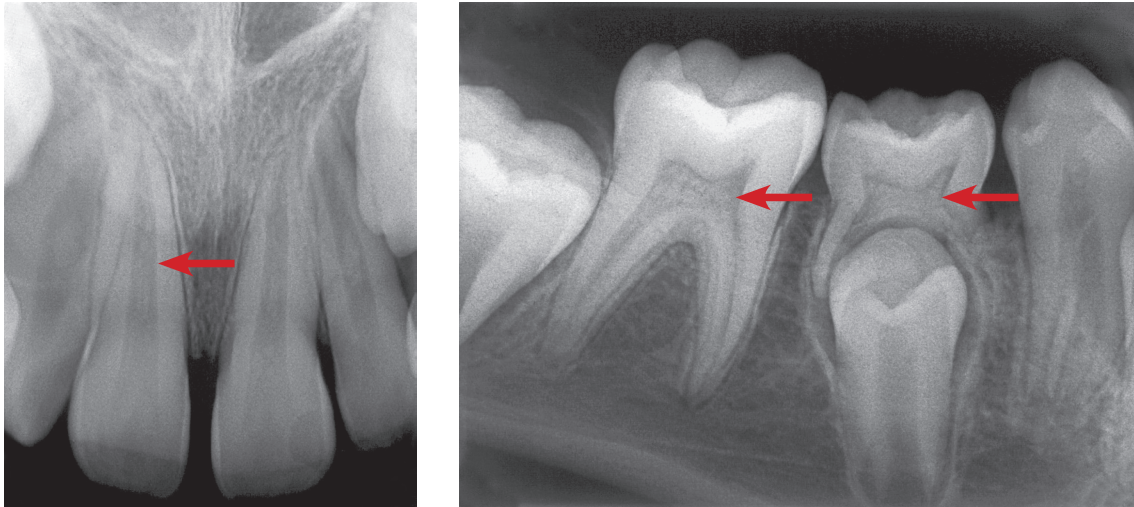


**Figure 5:** Diffuse pulp calcification, with granular radiopaque area inside the pulp space, induced by the same causes of pulp nodules: attrition, abrasion, caries and restorations. It represents one of the imagiological manifestations of early pulp aging, with multiple microareas of mineral depositions in the hyalinized extracellular matrix of the aged pulp. It is important to maintain clear and visible pulp boundaries (arrow). (In: Prof. Dr. Armelindo Roldi/ESFA - Santa Teresa/ES).

dodontist, in general, they do not offer difficulties of access to the channel entrances.

## 2 - DIFFUSE CALCIFICATIONS IN THE PULP

The image of the pulp space in the diffuse calcifications of the pulp remains with its clear and visible limits, but in the center there are numerous and



**Figure 6:** Metastatic calcification of the pulp in a nine-year-old boy, associated with hypercalcemia of systemic origin. It represents the deposition of minerals in multiple microareas of the normal extracellular matrix, in many normal pulps of the same patient, by excess of calcium in the blood. The maintenance of clear and visible pulp boundaries (arrow) is highlighted. (From: Prof. Dr. Fabrício Kitazono de Carvalho, FORP-USP).

tiny radiopaque points that occupy most of the radiolucent area of the pulp space (Fig 1 and 5).

They represent small areas of hyalinization, in which minerals were deposited, forming small and multiple areas of calcification and/or mineralization, but maintaining clear and identifiable pulp limits on radiographs and tomographies (Figs. 1 and 5). They have the same causes of pulp nodules, changing only in the way they settle.

### 3 - METASTATIC CALCIFICATIONS IN THE PULP

These cases are less common and, when they occur, involve many or all of the teeth, even if fully healthy (Figs 1 and 6). They are represented by small and multiple areas of calcification and/or mineralization that occur in normal areas of the healthy dental pulp, resulting from hypercalcemia (excess of calcium in the blood), but with pulp limits clear and identifiable on radiographs and tomographies (Figs 1 and 6).

The term metastasis means pathological migration of products (including mineral ions) to blood or lymphatic tissues from an initial lesion.

High hypercalcemia is associated with: hyperparathyroidism, hypervitaminosis D, bone metastasis, osteomyelitis, multiple bone atrophy and bone trauma. Minerals, especially calcium, leave to the tissues in great concentration and precipitate in the normal extracellular matrix, due to excess in the corporal liquids. Metastatic calcifications also occur in other parts of the body, and not exclusively in the pulp.

### METAPLASIA OR CALCIFIC METAMORPHOSIS OF THE PULP IS NOT PULP MINERALIZATION OR CALCIFICATION

Metaplasia, or pulp calcific metamorphosis is a response to the low intensity trauma known as dental concussion, in which the blood supply was partially affected by a mild injury with partial or temporary obstruction of the vascular

bundle entering the apical foramen to nourish the specialized connective tissue of the pulp.

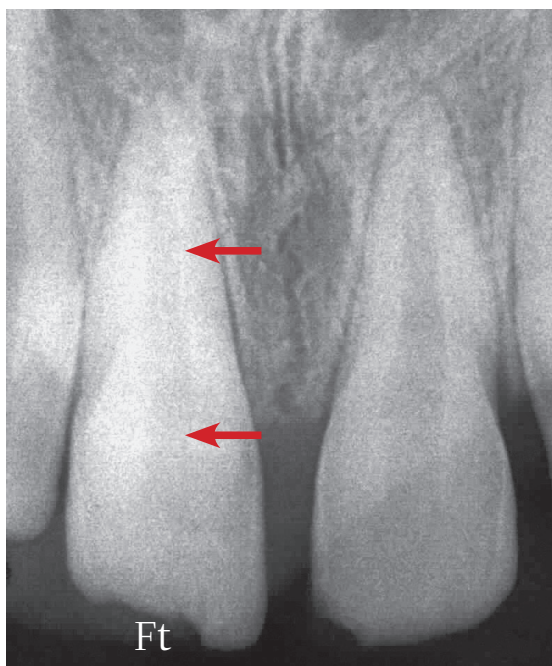
In order not to succumb to this mild and/or brief aggression, pulp cells in hypoxia, especially fibroblasts and perivascular cells, called pericytes, change their phenotype or biotype into odontoblasts. These cells, now randomly distributed throughout the pulp - far, near or in continuity with the dentin walls - begin to deposit irregular and poorly mineralized layers of dentine; a poorly made and disorganized dentin, which is now called dysplastic dentin.

In metaplasia, or calcific metamorphosis of the pulp, the pulp space - radiographic and tomographically well delimited by dentin walls and

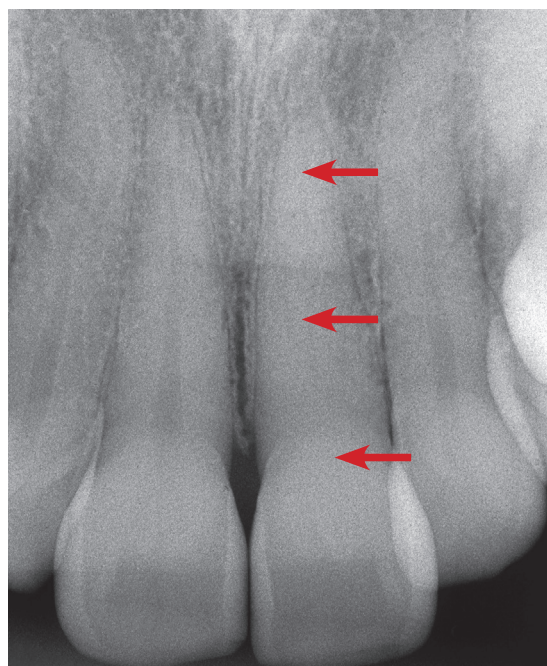
homogeneous in its radiolucency - is gradually being taken up by a radiopaque "fog", so that the pulp boundaries are extinguished and all the pulp space is replaced by a homogeneous radiopaque area, completely obliterating or erasing the pulp space (Fig 1, 7, 8).

In metaplasia, or calcific metamorphosis of the pulp, there is simply no deposit of minerals in a single or multiple focal mass, such as in pulp nodules and diffuse calcifications. There is dentin formation at all sites of the pulp; there are no nodules or focal masses, but a uniform formation in all directions, which diffusely in the images leads to the erasing of the pulp space, since it eventually involves the dentin walls (Fig 1, 7, 8).

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**Figure 7:** "Fog" with erasure of the pulp boundaries due to irregular and random formation of dentin in the pulp spaces (arrows), due to the great majority of the cells undergoing metaplasia or metamorphosis into odontoblasts in response to dental trauma months before. This fog and erasure of the pulp boundaries are typical signs of the metaplasia or calcific metamorphosis of the pulp. It is worth noting the comparison with the neighboring tooth with normal pulp spaces. In the impaired tooth, a fracture (Ft) of the enamel is observed, denouncing the occurrence of dental traumatism.



**Figure 8:** Complete obliteration (arrows) of pulp spaces by irregular and random formation of dentin resulting from metaplasia or metamorphosis into odontoblasts in response to dental trauma months before. This image is typical of metaplasia or calcific metamorphosis of the pulp. It is worth noting the comparison with the neighboring tooth with normal pulp spaces. (From: Prof. Dr. Armelindo Roldi/ESFA - Santa Teresa/ES).





**Figure 9:** Darkened incisor with “healthy” mineralized tissues despite the change in color, in a 30-year-old woman. The differential diagnosis should be between metaplasia or calcific metamorphosis of the pulp and aseptic pulp necrosis. The diagnostic definition should be made only with the analysis of the radiographic or tomographic images, since the color does not help to differentiate one from the other! (In: Profa. Dr. Leda A. Francischone).

This pulp reaction to dental concussion will only occur if pulp vitality is maintained, even if in precarious conditions. If there is complete rupture of the blood vessels in the apical third, the pulp evolves to aseptic pulp necrosis, because in order to occur metaplasia or metamorphosis, living cells still under metabolic conditions are required and to transform into an equally mature type.

This picture generates a much thicker dentin and gradually the enamel gives a more yellowish, brownish and even grayish color (Fig 9). The clinical sign of metaplasia, or calcific metamorphosis of the pulp, is the isolated darkening of the affected tooth, standing out among the others. Apparently, their mineralized tissues are “preserved” structurally, despite their altered color.

Metaplasia, or calcific metamorphosis of the pulp is completely painless in all its phases and its differential diagnosis is made with aseptic pulp necrosis. The only way to distinguish one from the other is by radiography and/or tomography. In

pulp necrosis, the pulp space is preserved, the pulp boundaries being prominent; while in metaplasia, or calcific metamorphosis of the pulp, the limits are erased and the pulp space occupied by a radiopaque fog that obliterates it.

The intensity and hue of the darkened color of the dental crown due to metaplasia, or calcific metamorphosis of the pulp, does not allow it to be distinguished from aseptic pulp necrosis, which is its differential diagnosis when a tooth appears darkened and apparently healthy.

## FINAL CONSIDERATIONS

1. Dysplastic dentin deposited in pulp spaces by cells that have been transformed into odontoblasts to survive a dental concussion should not be called pulp calcification or mineralization but metaplasia or calcific metamorphosis of the pulp.

2. Pulp fibrosis and hyalinization, followed by deposition of minerals on hyalinized areas of collagen in fibrous pulps are part of early pulp aging, due to the inadequate use of teeth as in severe attrition, abrasion, cavities and restorations, without any relation to the age of the individual, and should be called pulp nodules and diffuse calcifications of the pulp. They indicate that this aged pulp has low reactive and restorative capacity against conservative operative procedures.

3. Pulp calcifications and metaplasia or calcific metamorphosis of the pulp are different processes and diseases among them as to the causes, clinical pictures and clinical conducts to be adopted.

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