Long Term Histological Response of Hemisectioned Exposed Primary pulps. *An in vivo* Study

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*The **aim** of this study was to analyze the pulp behavior 17 hemisectioned primary second mandibular molars, exposed into the oral environment. The mesial crown and root portions were extracted after 8 months and analyzed histologically. **Results:** The cardinal signs such as pain, sensitivity and necrosis were not found in any of these teeth with the exception of one case which had a previous restoration. The formation of pulp polyps, pulp calcifications and pulp obliteration were seen as a normal physio-pathological response. **Conclusions:** Exposed pulps, reacted forming pulp polyps and in a similar fashion to exfoliating primary teeth but in an accelerated manner.*

Keywords: *dental pulp, primary teeth, hemisection, physiology, pulp polyps, pulp calcification, pulp stones.*
J Clin Pediatr Dent 34(1): 19–24, 2009

INTRODUCTION

The human dental pulp in primary teeth is a noble tissue from which stem cells are being harvested to treat disease and injury.[1,2] Maintaining pulp vitality of a clinically exposed dental pulp has been the target of various clinical procedures. Unfortunately, due to past unreliable results,[3] we neglected its recovery potential, paying more attention to management of the pulp disorders.

Pulp therapy in primary teeth is one of the most controversial areas in pediatric dentistry. Several treatments options have been developed and different medicaments used. However, no consensus has been reached due to different inherent problems. For example, in vital pulp therapy, formocresol has been, for the last 70 years, the most widely used substance. Even with the acceptable clinical and radiographic results, concerns about the toxicity, potential mutagenicity from systemic contamination has pushed for the search for more biocompatible substances.[4-6]

When caries penetrates the root canal system or an abscess exists, the elimination of microorganisms from the root canal still present several problems mainly related to the material used as well as anatomical variables within the root canal system.[7-10] Due to all these flaws, health concerns and today's unpredictable results we are turning back towards more conservative treatments, relying on the pulp's potential to heal

Recently, new reports, have been probing again on pulp's ability to respond to injury.

Indirect pulp treatment is a technique which has resurfaced and poses a renovated approach in the treatment of deep dentin active carious lesions in which only the non-remineralizing tissue is removed and a thin layer of demineralized tissue is left at the deepest site of the cavity to avoid pulp exposure. It has shown a high clinical and radiographic long-term success rate in primary teeth, granting a conservative alternative treatment in primary teeth with deep carious lesions.[11-15]

In case of minute pulp exposures in deep caries lesions a new material is being tested. Enamel Matrix Derivative (EMD) is a protein biomaterial derived from the extracellular enamel matrix rich in amelogenin and amelin. In contact with the pulp tissue, it differentiates odontoblasts to form new dentin, seals the exposed site, produce tertiary dentin while maintaining the normal pulpal function in primary teeth.[16-18]

Looking at the pulp, new research seems to bring back old memories of self healing, based on the ability of the inflamed dental pulp to return to a healthy state once the noxious stimulus has been removed. For example, the presence of a hyperplastic chronic pulpitis, known as pulp polyp presents a challenge. This exofitic, non painful, granulation tissue reaction is produced in healthy young pulps exposed to mild chronic stimulus.[19-22]

Dental fractures in permanent teeth with pulp exposure is generally asymptomatic. Cvek found Granulation-like tissue at the exposure site 48 hours after injury, hyperplasia

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Figure 1. Controlled slicing technique. **A.** Initial view. **B.** Slicing of the distal crown portion of the second primary mandibular molar of 1.5 to 2mm with a 169L high speed bur. **C.** Hemisection and extraction of the distal crown and root portion of the second primary molar. **D.** Bodily drift of the first permanent molar. **E.** Crown uprighting, prior to the extraction of the mesial crown and root portion of the second primary molar. This portion was used for the pulpal histological analysis. **F** and **G.** Bodily movement of the first permanent molar. **H.** Eruption of first premolar with bodily drift of first permanent molar.[24]

of the pulp one week after injury and a pulp polyp covered with plaque 3 months after injury.[23]

In summary, the management of the pulp tissue appears to point towards more conservative treatments. Knowing its physiological response to injury, this study will look at the long term reactions to pulps exposed *in vivo* into the oral environment in children.

MATERIALS AND METHODS

The sample consisted of patients with 17 overretained second primary mandibular molars with complete root formation from congenitally missing second premolars. The absent teeth were detected after routine dental examination between the ages of 8 to 11 years from intra oral radiographs (55.8%) or from orthodontic work up (42.2%).

The molar sample comes from a controlled slicing study (Figures 1 and 2).[24] This method is used to elicit the physiological bodily migration of the first permanent molar.

It consists of an initial 1.5mm bucco lingual section of the distal aspect of the second primary molar with a new 169L stainless steel bur under constant water irrigation (Figure 1). After the bodily mesial migration of the first permanent molar (4 months approximately) and under local anesthesia, a hemisection of the second primary molar is accomplished with a new 169L stainless steel bur under constant water irrigation. The distal aspect of the crown and root is removed with a anterior tooth forcep for primary teeth being careful not to disrupt the mesial residual portion. After 8 months, once the permanent molar migrates bodily, the mesial portion of the second molar is extracted under local anesthesia and the sample is prepared for histological analysis, prior to signing a parental informed consent. All teeth were asymptomatic, during the time exposed to the oral environment and none were extracted due to unwanted reactions.

Those teeth were immersed in a 4% buffered formaldehyde solution, decalcified, sectioned and died with H&E.

The pulp tissue for its analysis was divided in two parts. Section exposed to the oral environment., coronal pulp and upper third of the radicular pulp (Figures 2 and 3). The apical radicular pulp was not analyzed due to the presence of healthy tissue with abundance of collagen fibers and sometimes calcified tissue or pulp stones embedded in dentin.

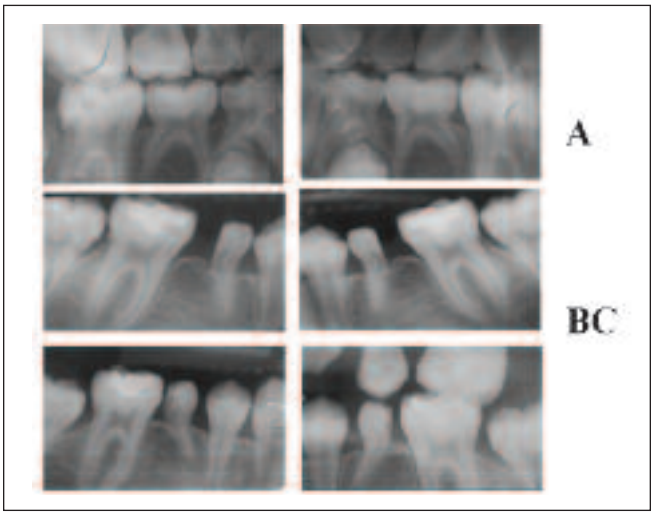

Figure 2. Radiographic progress of controlled slicing on a patient with congenitally missing bilaterally second premolars. **A.** Initial view. **B.** After hemisection **C.** 8 months after hemisection and extraction of the distal crown and root sections of the second primary molar. Note the bodily mesial drift of the first permanent molar. At this time, extraction of the mesial crown and root portions was done and samples were prepared for histological analysis.[24]

RESULTS

Histopathological results from studied specimens are shown in tables 1 and 2.

The changes in the medium and apical portions of the root were not reported as they are not different to the clinical observation from exfoliating teeth.

Table 1: Distribution of variables seen in coronal pulp

Studied Variable	Coronal Pulp (# Cases)
Pulp polyp	7
Pupo obliteration	4
Fibroblastic polyp	2
Reticular pulp	2
Dentinal bridge	1
Insufficient material	1
Total	17

Table 2: Distribution of variables seen in radicular pulp

Studied Variable	Radicular Pulp (# Cases)
No root	3
Pulp obliteration	6
Pulp calcifications	3
Healthy pulp	3
Not assessable	2
Total	17

DISCUSSION

It was worth noticing that pulp exposure from hemisection for over eight months did not display the probable cardinal signs such as sensitivity, pain and necrosis. We were expecting and prepared to extract the final segment in case of any unwanted reaction. This was the first interesting result, which prompted us to complete this study.

Interestingly, some patients complained only of sensitivity from the first distal slicing and not from the hemisection. A few presented pain from food impaction that receded once debris were removed with brushing.

Physiologically, pulp vascularity increases in its coronal portion. The dental pulp is encased in a rigid non expandable shell. In case of carious pulp contamination, bacterial infiltration, produces, inflammation, pain and pulp stasis which derives in cellular death. In a hemisectioned tooth, because the exposed pulp is open into the oral cavity, it allows all the inflamed tissue to drain freely letting nutrients and physiological functions to be maintained[19,25] (figure 4).

In relation to the lack of pain, removal of part of the pulp tissue modified the sensitivity and the inflammatory reaction.[26-27] Seemingly, this procedure could result in the degeneration of the cell bodies located in the trigeminal nerve, the main sensory ganglion and the peripheral nerve transmitting its stimulus from an injured tooth.[28] Locally, within the tooth itself, nerve bundles containing mostly unmyelinated and some myelinated nerves pass thru the apical foramen. These unmyelinated nerves have been shown to reduce the blood supply when stimulated which could reduce pain.[28]

A paper by Abdelhamied, showed the histological response of extracted primary mandibular second molars from congenitally missing permanent succesors. The author showed a compromised circulation, pulp degeneration, vacuolation, the presence of pulpal stones accelerated dentin deposition, and hypercementosis. In our case, the main degenerative changes were seen in the radicular pulp where 6 cases presented pulp obliteration and 3 pulp calcifications (Figures 5 and 6). They tend to develop from age and irritation. This irritation resulted from the large pulp exposure. However, they are more predominant in the coronal portion as pulp stones which were not seen in our sample.[27] In the coronal portion pulp obliteration (4 cases) was the main component found in response to the hemisection. Also no hypercementosis developed, possibly from the young age of our population group.

From this result, the possibility of intentional or not intentional (not caries related) pulp exposures for long periods with no pulp treatment could be a possibility without incurring in additional pulp treatment costs (pulpotomy).

In the coronal zone, 9 cases showed the formation of pulp polyps, while 4 showed pulp obliteration (figures 4 and 7).

The presence of pulp polyps also known as Chronic hyperplastic pulpitis responded to the mild chronic irritation of the pulp tissue. It is a unique response to the exposed pulp into the oral environment maintaining its full vitality. The large exposure of pulpal tissue resulted in a chronic inflammatory response that stimulated the formation of this granulation tissue reaction. New capillaries formed, with almost no nerve ending at its surface that contrasts with the rich innervation and sensitivity to found in exposed pulps. The epithelized polyps appeared similar to oral epithelium with a normal appearing basal lamina and cellular appearance. Fulton suggested that this epithelium covering is formed by the pulp polyp and not from oral epithelium.[28] It has been shown that polyps epithelize more frequently in primary than permanent teeth.[19,25 31] Some authors also reported the presence of mast cells, which are only present in chronic phases of pulp inflammation,[30] phenomena that was not found in our sample, possibly because hemisectioned teeth were extracted before the first year.

These pulps showed a greater physiological response compared to Abdelhamied article. This could be related to age when those teeth were extracted (19 to 33 years). Apparently age, generates continuous dentin deposition and narrowing of the pulp chamber and canals decreasing circulation leading to the degenerative changes seen.[21-22] In our study, teeth were much younger (8 to 9 years) with the presence of a large blood supply, which maintained the tooth in a "healthier" and asymptomatic state.

It is very difficult to contaminate healthy dental pulps even after mechanical exposure and maceration.[20] This is due to rich blood supply and favorable immune response from the young dental pulp. In our case, mechanical pulp exposure from hemisection did not show any bacterial contamination. No chlorhexidine mouth rinses or antibiotics were

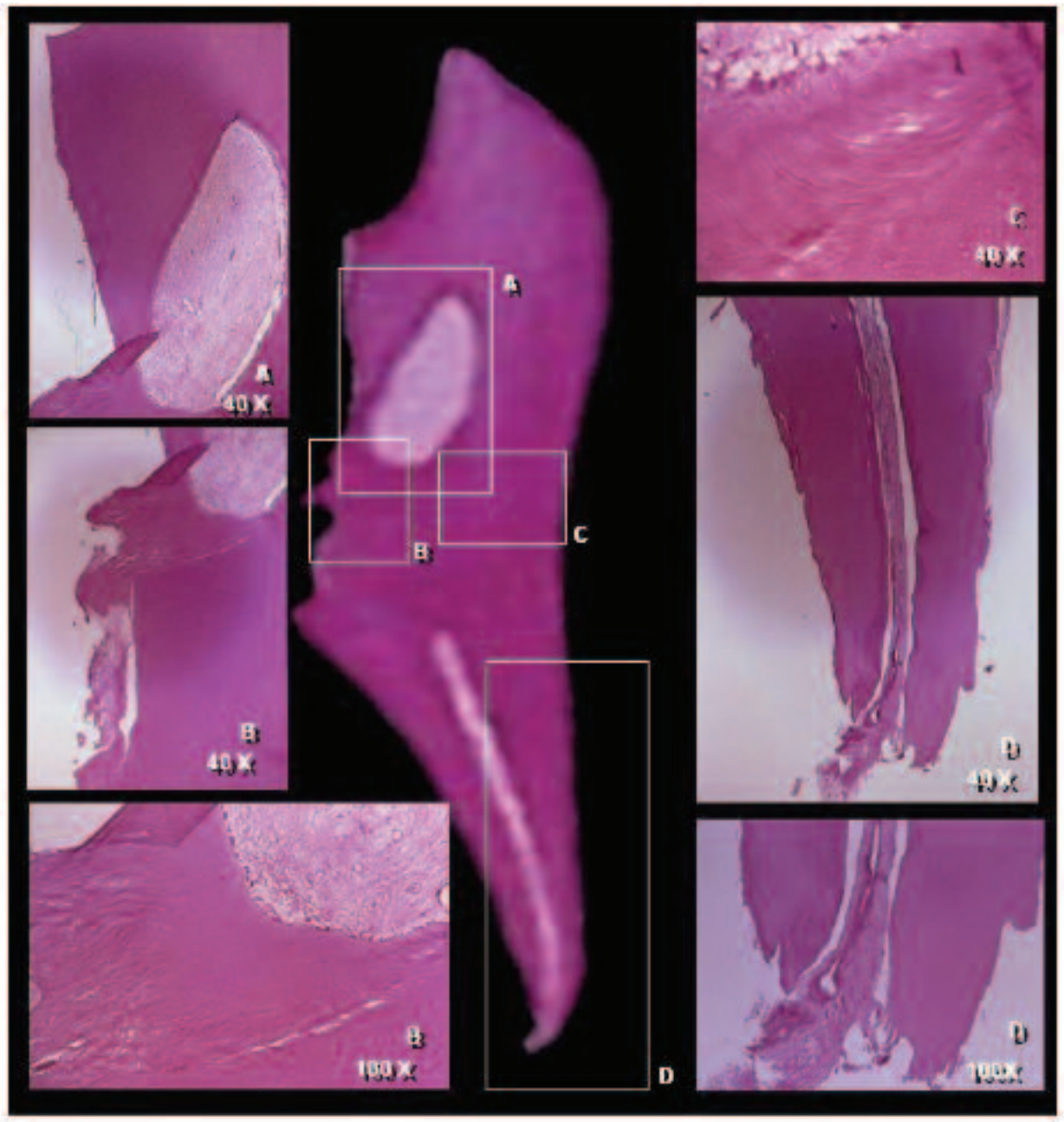

Figure 3. Histological figure of the mesial hemisectioned molar, showing the different sections studied. **A.** Pulp chamber. **B.** Lower portion of the pulp chamber. **C.** Upper portion of the mesial root. **D.** Apical radicular area

necessary. All sectioned teeth had no restorations or caries thus presented no bacterial contamination prior to the hemisection, with the exception of one case, which had a previous restoration. Interestingly, this case (figure 8) was the only one to present bacterial growth with areas of necrosis.

Some responses seen in our sample behave in the same manner to physiological changes occurring with age. The pulp volume decreased and size was reduced by secondary dentin apposition (figure 5). As a tooth ages, the number of blood vessels and nerves decrease and become more inactive.[27] This reaction was not seen in the coronal portion of the exposed pulp due to a good vascular and immune supply.

Pulp degeneration and calcifications could occur as a result to a reduced blood flow within the canal and a decrease in the cell number from the pulp hyperactivity as a reaction to injury (hemisection). Reticular atrophy (figure 9) was seen in 2 cases and as Boyle[32] suggested it is normal reaction to pulp aging. He suggests that this reaction is due to an increase in intercellular fluid buildup and a reduction of cells within the pulp.

The intention of this study is not to suggest leaving pulp tissue open into the oral environment, but to show pulp's potential to defend itself. New technologies should explore the prospect of pulp regeneration.

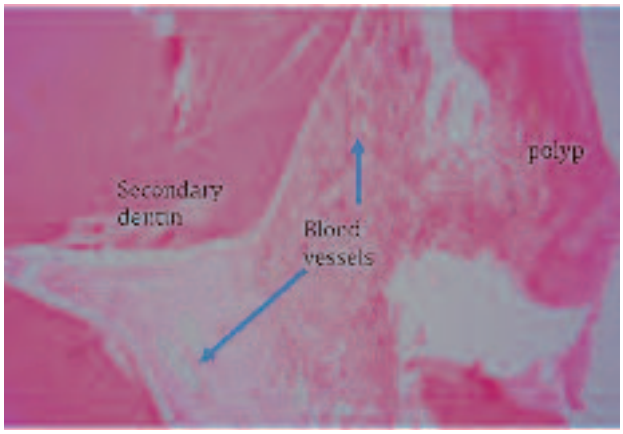

Figure 4. Microphotograph showing the presence of a pulp polyp, accompanied with dentin appositon and an increase in the presence of blood vessels H&E 25x

Figure 5. Microphotograph of radicular pulp, with complete pulp obliteration in the mid and lower root portions. H&E 40X.

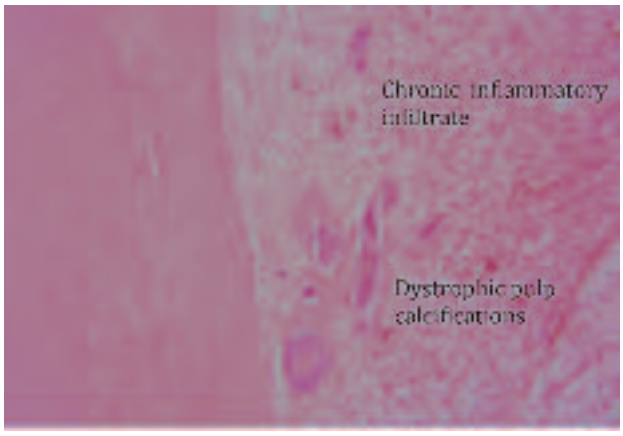

Figure 6. Microphotograph of the root portion showing signs of chronic inflammation and dystrophic pulp calcifications. H&E 25x.

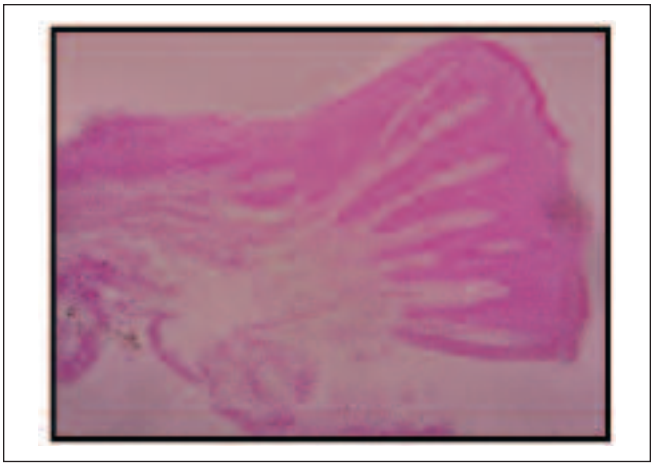

Figure 7. Microphotograph of a pulp polyp. Note the keratinized epithelium. H&E 25x.

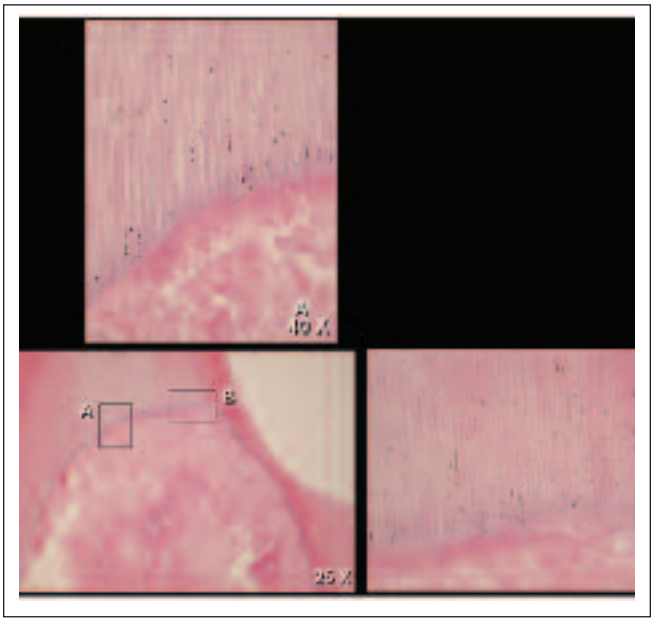

Figure 8. Microphotograph of a pulp showing degeneration and bacterial invasion. H&E 40x, 50x and 100x. This was the only tooth that had a previous restauration. One can see bacteria migrating up the dentinal tubules.

CONCLUSIONS

Hemisectioned primary molars exposed into the oral environment for 8 months did not display the expected cardinal signs, such as pain, sensitivity and necrosis. Exposed pulps, reacted forming a pulp polyp and responded in a similar fashion to exfoliating primary teeth but in an accelerated manner.

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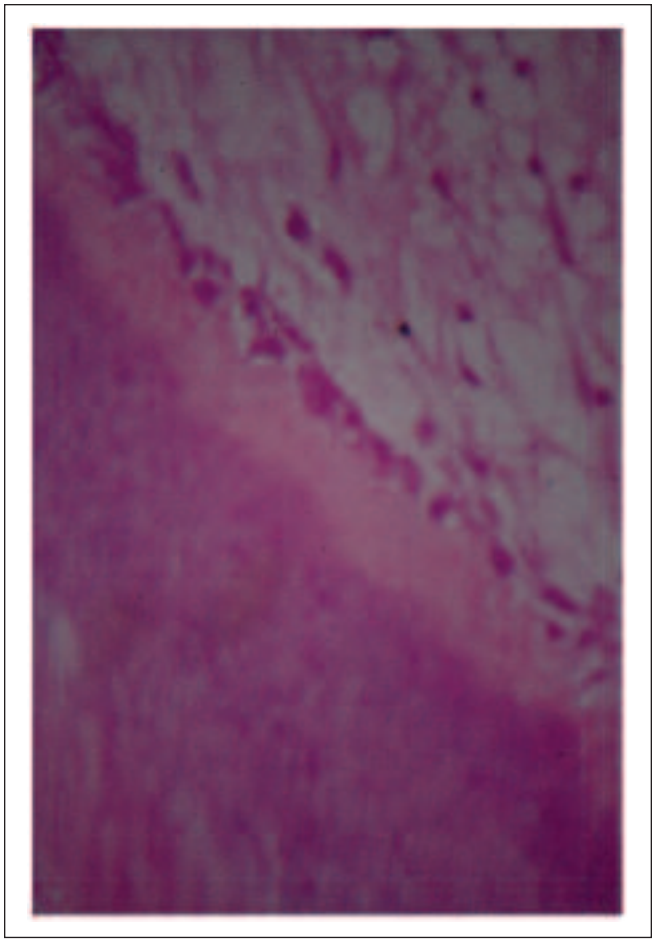

Figure 9. Microphotograph showing the presence of dentinal tubules, secondary dentin and odontoblastic cells bordering a reticular pulp. H&E 100x.

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