DOI: 10.18044/MEDINFORM.202292.1566 ISSUE 2, 2022

Chemical-Mechanical Removal Of Infected Dentin in caries treatment

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Abstract

In the last year is most important to keep the vitality of the dental pulp because when it is necessary to make endodontic treatment, results are only sometimes predictable. Most authors take care of indirect and direct pulp treatment and vital pulp therapy. The important question is how to remove the infected dentin. The ways that show preventing the affected layer of dentin are interesting. The aim is to investigate removing infected dentin and keeping affected dentin in clinical cases of deep caries lesions and hyperemia pulpae with chemical-mechanical medication of papain gel (Brix 3000).

There are described of two clinical cases. The first one is with diagnoses of caries profunda. The results of removing infected dentin only with papain gel have given possibilities to prevent the opening of the pulp. The second case is with a diagnosis of hyperemia pulpae. With CBCT, an investigation has established that the distance to the pulp was about 0.6 mm. Using the method of chemical-mechanical removal of infected dentin with papain gel, we did not have direct communication with the pulp. Today, published literature confirms that the preparation with rotary burs is harmless, non-irritating, and non-damaging to healthy tissues in the oral cavity. Brix 3000® successfully removes infected dentin without affecting the affected one in the carious lesion. This is fully in line with the modern concept of minimally invasive dentistry. The lack of pain, overheating, vibration, and noise, and the biological and gentle action towards the dental pulp when applying to make it an indispensable assistant to the dentist in children and adolescents, as well as in adult patients.

Keywords: *chemical-mechanical removing of caries; papain gel; Brix 3000; infected dentin; affected dentin; ozone treatment.*

Introduction

In the last year is most important to keep the vitality of the dental pulp because when it is necessary to make endodontic treatment, results are only sometimes predictable. Most authors take care of indirect and direct pulp treatment and vital pulp therapy(1). The critical question is how to remove the infected dentin. The ways that show preventing the affected layer of dentin are interesting.

Infected dentin is soft and located closer to the tooth surface. It is called external carious dentin and is characterized by: the presence of bacteria; low mineral content; irregular, denatured collagen; significant amount of bacteria. Histologically, this area is necrotic and contaminated. The appearance of infected dentin is wet, like a pomace, and unstructured. In its deepest parts, it is cloudy, dry-looking, and has the appearance of shagreen skin (leathery dentin). Microscopic examination shows severely altered dentinal tubules filled with bacteria. Infected dentin cannot be recovered(2).

The next layer located in the direction of the dental pulp is the affected dentin (internal carious dentin). Its thickness is about 1.75 mm. The demineralization of the intertubular dentin and the initial formation of intratubular fine crystals on the anterior front of the carious lesion characterizes it. Because the tubular lumen is filled with minerals, under a light microscope, its appearance is transparent. Histologically, this area is referred to as demineralized. Inconsistency-affected dentin is softer than normal hard dentin as demineralization processes occur within. The collagen fibers of the intratubular dentin in the area of the affected dentin have a preserved structure, regardless of acid attacks on the mineral and organic structure of the dentin. The dental pulp is viable. Most importantly, there are no bacteria in the affected dentin area. Affected dentin can be remineralized and restored. To preserve the vitality of the tooth, it is essential to keep this area (3,4). There are differences in the development of the carious process in the dentin, depending on whether it is acute or chronic caries.

Establishing access to affected dentin in clinical practice is a difficult task. Distinguishing infected from affected dentin can be aided by light fluorescence, staining solutions, or other caries indicators (5).

The aim is to investigate removing infected dentin and keeping affected dentin in clinical cases of deep caries lesions and hyperemia pulpae with chemical-mechanical medication of papain gel (Brix 3000).

Adverse effects associated with the removal of infected dentin with rotating instruments.

Removal of infected dentin with rotating instruments (burs) is associated with side effects that are unfavorable for maintaining the vitality of the dental pulp. This include:1. Dehydration (aspiration and air cooling damage the odontoblast growths in the dentinal tubules and the odontoblasts themselves);2. Overheating (damage to the odontoblasts and odontoblast growths);3. Applying pressure on the dentin and vibrations (formation of cracks and microcracks in the enamel and dentin, thus creating a path for microorganisms to the dental pulp);4. The type and condition of the bur with which the carious tissue is removed: blunt and non-cutting bur; sharp and cutting bur; diamond bur; ceramic bur; steel bur; applied with or without water cooling (1).

All these factors create an opportunity to form so-called "dead paths" in the dentin, i.e., places in the dentin where the dentinal canals are filled with necrotized odontoblast growths. These are ideal areas for the development of microorganisms that are present in the carious outbreak. The number of microorganisms in

infected dentin is immense - 16 million bacteria; after removal with Brix 3000, only 100 in affected dentin (unpublished data).

Overcoming the shortcomings of removing carious mass with rotating tools and creating new materials are the basis of minimally invasive dentistry (26). Essential in the minimally invasive dentistry approach is the removal only of damaged by the carious process tissue - damaged enamel and infected carious dentin. In contrast, the affected dentin is preserved to restore the functions of the dental pulp (6, 7, 8). Such techniques are air abrasion; sonic abrasion; laser ablation; manual removal; chemical-mechanical preparation (4).

Chemical-mechanical removal of infected dentin.

Special attention is paid to the chemical-mechanical removal of infected dentin from the carious lesion in treating dental caries. M. Goldman first launched this idea in 1970 (20). It is based on the fact that 5 % sodium hypochlorite dissolves organic matter in the root canal. This foundation was created as the first means for treating dental caries without using rotary cutting burs in dentin. The Carisolv system (MediTeam Dental, Sweden) contains mainly sodium hypochlorite, three types of aluminum acids, carboxymethylcellulose, and water. Caridex (1984) was subsequently developed, followed by Carisolv singlemix (1998); Carisolv Multimix (2004); Biosolv (2006); New Carisolv System (2013) (9). Experience has shown that products based on sodium hypochlorite have several disadvantages: unpleasant odor and taste, a long time for application, etc. This led to the development of another group of agents for chemical-mechanical preparation based on the enzyme papain. The following products were implemented - 2003 Papacarie (Formula e Acao, Sao Paulo, SP, Brasil); 2009 - Papaina plus; 2011 - Papacaine Duo; 2012 - Care Care (Unibiotech Pharmaceuticals, India) to reach Brix 3000® (Argentina) created in 2014 (10, 11).

Papain is a proteolytic enzyme derived from the bark of immature papaya (Carica papaya). It has been determined that the enzyme has antibacterial, antifungal, and anti-inflammatory properties. Studies related to the action of papain gel date back to before 1965 (12). Papaya has a beneficial effect on the human organism by supporting the liver in the treatment of cirrhosis; aiding liver detoxification; protecting against joint inflammation; destroying bacteria (E. coli, Salmonella, Staphylococcus) and viruses (dengue); stimulating the reproductive functions of the female body; has antitumor and anticancer effects; destroys some parasites in the gastrointestinal tract (13). In dentistry, it is used to treat dental caries (10,14,15).

Brix 3000® is an innovative product for removing infected dentin based on the papain enzyme. Unlike similar products on this base, the concentration of papain in the product is exceptionally high, 3000 U/mg, and is stabilized by a special E.B.E. (encapsulated buffer emulsion) patented technology. This allows the final product to have high proteolytic activity for removing damaged collagen in the infected dentin. Developed by this technology, concentrated papain gel can be stored at room temperature, has a storage period of 2 years, and has antibacterial and antifungal efficacy (16,17). The product has no toxicity and does not cause inflammation and sensitization of healthy tissues. It is important to note that it loses its enzymatic activity in contact with healthy tissues. Various treatment protocols are easy and can be used in acute and chronic caries and the initial stages of dental pulp inflammation. In different clinical situations, the application of Brix 3000® has different duration and frequencies. In massive infections and multiple caries, Torresi and Bseremi (2017) suggest that the preparation be left under temporary restoration for maximum results (18).

Mechanism of action, antibacterial activity, and biological tolerance of Brix 3000®

Papain gel dissolves the non-covalent bonds of damaged collagen fibers (hydrogen bond between peptides by electrostatic hydrolysis) but does not dissolve cross-covalent bonds. The preparation is neutralized by reaching intact collagen fibers (affected dentin) by two mechanisms: physiological, through alpha-1 chymotrypsin, and microphysiological, through the intact collagen fibers (5,15). This is why the papain enzyme stops working at the level of affected dentin. That is, the demineralized affected dentin is not affected when reached by the papain gel.

Another important point in applying Brix 3000® is the antibacterial activity of the preparation. Several studies have shown that microorganisms from the group of oral streptococci (90%) are essential in the etiopathogenesis of dental caries; Candida albicans, Peptostreptococcus spp., Enterococcus,faecalis, and others (19). Studies conducted at the University of Argentina have shown that Brix 3000® has antibacterial activity against Streptococcus mutans and Enterococcus faecalis, similar to the action of chlorhexidine(20). Juntavee and co-authors also found suppression of Streptococcus mutans in a laboratory study of papain gel (17). Comparative studies conducted by Hammer show a higher antibacterial activity of papain gel compared to products based on sodium hypochlorite used for chemical-mechanical preparation (21). The antibacterial properties of papain gel enable the prevention of secondary recurrent and multiple carious lesions. It takes time to eliminate the causative agents of caries (Streptococcus mutans, Lactobacillus spp., Veillonella spp.). Silva Júnior and co-authors found that combining papain gel with photo-activated therapy kills cariogenic microorganisms significantly better (11). Placing Brix 3000® in a cavity cleaned of infected dentin for a few days would likely help reduce the microbial flora and the use of ozone gas in the cavity.

Ismail and Haidar conducted a comparative clinical study. They found no statistically significant difference in reducing microorganisms after caries tissue removal with a ceramic bur and papain gel Brix 3000® (2). Removing with Brix 3000® infected dentin is statistically significantly less painful and traumatic. The time to remove necrotic carious tissue is longer with papain gel than with ceramic bur (2).

Regarding the biological tolerability of Brix 3000®, in vitro studies on fibroblast cells have shown that papain is biologically tolerable (10,14). Mainly, it is completely non-toxic to the human body.

Santos et al. found that chemomechanical therapy with Brix 3000 was effective, efficient, and non-cytotoxic or genotoxic due to reduced removal time and lower cytotoxicity compared to Papacarie Duo and conventional bur treatment (22).

The results of the application of Brix 3000® are confirmed by clinical studies (8, 26). Torresi and Bseremi studied 150 patients with dentin removed with Brix 3000®. In 62 patients, a single application of Brix 3000®, without discomfort, was sufficient to remove the infected dentin. The authors conclude that this chemical-mechanical method proves to be a good and painless alternative for removing carious mass (18).

Using a natural biological, non-toxic papain enzyme to remove infected dentin in treating caries and its complications gives us reason to label its use as a bio-mechanical preparation.

Indications of the use of Brix 3000®

Doses for use in the application of Brix 3000® are different, depending on the size and type of caries. Thus, in children, one dose is needed for the painless removal of damaged dentin. In adults, one and sometimes more doses are required due to the larger volume of hard tooth tissue and the extent of carious destruction. In acute carious processes, it is desirable to wash off the applied papain gel and then manually excavate the infected dentin. In chronic caries cases, washing off the preparation used in the cavity is not necessary. The process of necrotomy is manual. The preparation is indispensable in patients with phobias to dental treatment, with defects near the dental pulp. As no allergic reactions to Brix 3000® have been identified to date, it is the first choice in patients with a history of drug allergy. In addition, with their vasoconstrictor effect, anesthetic solutions could impair the blood supply to the dental pulp and adversely affect the preservation of its vitality.

In summary, the indications for using Brix 3000® are patients with phobias to dental treatment - children, patients with neurosis; patients with allergy to anesthetics (established or unexamined); Patients wishing to apply alternative and natural methods for treatment of dental structures affected by caries; In the treatment of acute dental caries; In the treatment of chronic dental caries; In the treatment of multiple carious lesions; For the atraumatic excavation of carious dentin in biological therapy. It expands the indications for maintaining the vitality of the pulp tissue and prevents its inflammatory diseases (hyperemia pulpae, pulpitis chronica ulcerosa incipiens).

The technique has some drawbacks. It takes more time to assemble bio-mechanical preparations than the application of rotating techniques, which determines the complexity of the method. However, the prolonged duration refines and details the procedure for removing infected dentin and is an integral part of the minimally invasive approach to caries treatment by current treatment trends. The careful impact on the dentinal tissue is determined by the nature of the carious process and the difficulty in distinguishing infected from affected dentin. The method of necrotomy is manual. A set of hand tools is needed to conveniently perform the manipulation (hand excavators). This is successfully compensated by the lack of pain during treatment, the biological approach to dental tissues, and the lack of noise, vibration, and heat.

Patients with diagnoses such as Caries media, Caries Profunda (24), Hyperemia Pulpae, and Pulpitis chronica ulcerosa incipiens (23) were also observed for 9-12 months. In all of them, the vitality of the tooth is preserved, regardless of the development of the carious process near dental pulp.

Use of Brix 3000® in the treatment of Caries Profunda (clinical case)

A 17-year-old patient with deep carious destruction of the medial surface of tooth 46 was diagnosed with Caries profunda (Figure 1) (16). The preserved occlusal enamel above the carious lesion was removed with rotating tools. The carious mass was treated with Brix 3000® papain gel for 2 minutes, washed, and excavated atraumatically using hand tools only (Figure 2). Figure 3 shows a visualization of the dentinal wound („leathery" dentin) and a caries indicator. The dentinal wound was washed with distilled water and ozonated for 24 seconds (Figure 4). The treatment of deep caries of tooth 46 is completed with the restoration of glass-ionomer cement and composite material.

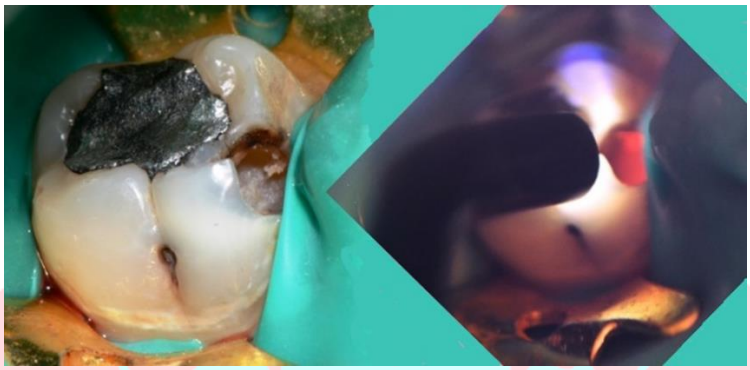

Figure 1. Tooth 46 at initial examination and with light fluorescence with FaceLight.

Figure 2. Applying Brix 3000® at the time of excavation with hand curettes.

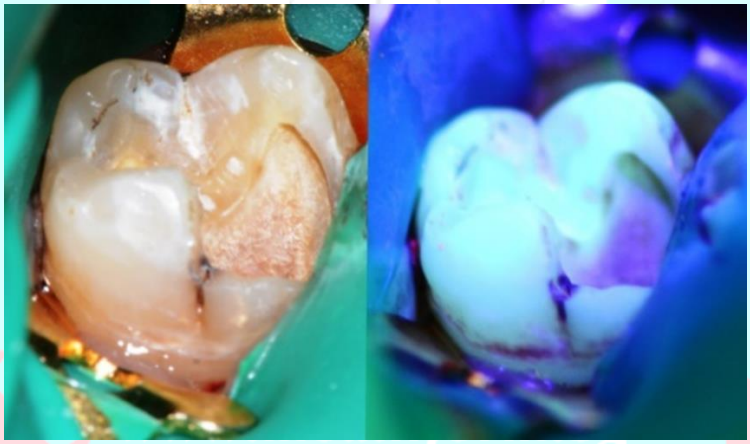

Figure 3. Reaching „leathery" dentin - visual inspection and with light fluorescence.

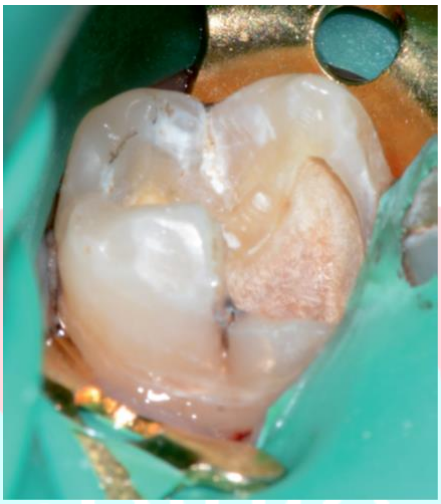

Figure 4. Type of dentin after ozonation and before restoration
Examination after 12 months reveals the preservation of the vitality of the dental pulp.

Use of Brix 3000® in the treatment of Hyperemia Pulpae (clinical case)

Using transillumination with Face light (W&H), a carious lesion on the medial surface of tooth 24 was found in patient IV (18 years old) with anamnestic evidence of pulp hyperemia. X-ray examination confirmed the presence of a deep carious lesion medially on tooth 24, adjacent to the dental pulp. EPT (electropulp test) examination established two mA values and confirmed the preliminary diagnosis of Hyperaemia pulpae (Figure 5 A, B).

Figure 5 A. Intraoral type of tooth 24; B. X-ray image of tooth 24 showing a medially located significant carious defect near the dental pulp.

The patient reported a phobia of dental procedures, which delayed their visit to the dental office for treatment. To gently remove damaged dentin and protect dental pulp without anesthesia, a bio-mechanical preparation using Brix 3000® was chosen. After the detection of caries, with rotating cutting burs (removal of enamel only), the infected carious mass with light yellowish color was revealed, which suggested rapid development of the process and the possibility of opening of the dental pulp (Figure 6).

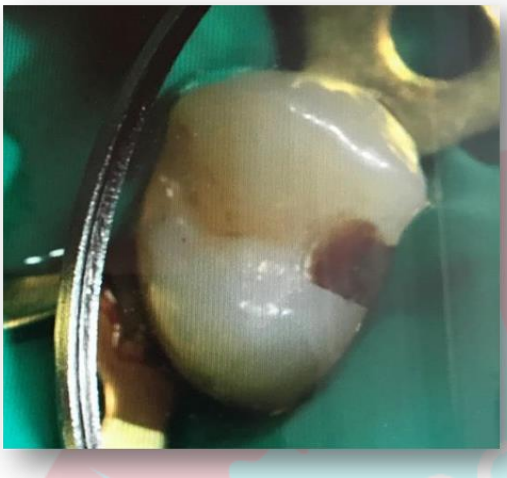

Figure 6. Detection of the carious focus of tooth 24 medially. Light yellow carious dentin is visible.

Figure 7. Tooth 24 after the final removal of the carious dentin, the surface is relatively smooth.

The application of Brix 3000® was carried out in 2-3 minutes. After each application, the softened infected dentin was carefully scraped with hand curettes. Due to the liquefaction of the carious mass, the detergent was washed off with distilled water for better visibility. Brix 3000® was applied three times, and the undermined enamel was removed step by step via traditional methods. After the necrotomy of the infected dentin, an area with a transparent dental pulp is seen (Figure 7). The surface of the cleaned cavity is relatively smooth but not shiny (like it is after removal with rotating cutting tools) (Figure 7).

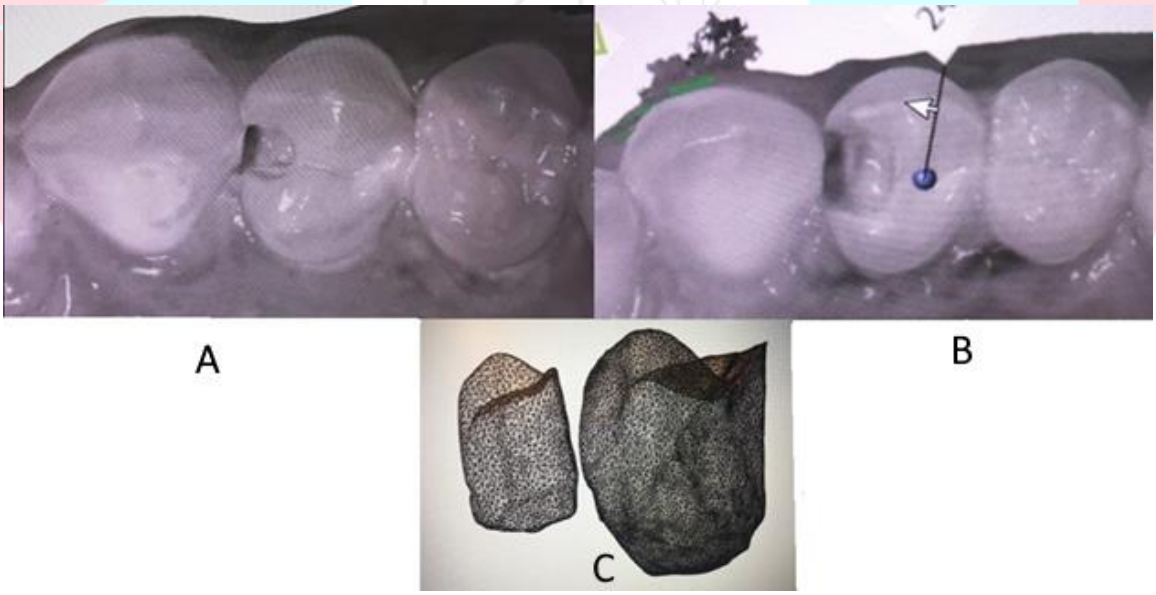

Figure 8 A. Scanning of tooth 24 immediately after the initial detection of the carious outbreak; B. Tooth 24 scan after final removal of carious dentin with Brix 3000®; C. Digitally produced volumes of the carious cavity after the initial detection of the carious focus and after the final removal of the carious dentin.

The difference in the size of the formed cavities after revealing the carious focus and after cleaning the carious mass only with papain gel (Brix 3000®) can be seen in Figure 8 A, B. By digital scanning and making a virtual model of the formed cavities as is done for inlays – figure8 C.

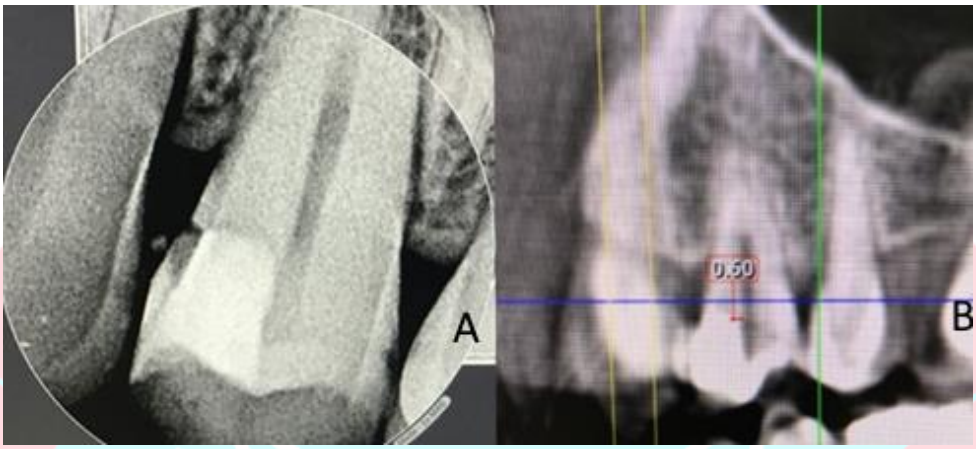

Figure 9A. X-ray image of tooth 24 after placement of BIODENTIN; B. CBCT of tooth 24. The location of the dental pulp at 0.6 mm from the restoration is visible.

An X-ray image of tooth 24 after BIO-DENTIN placement of can be seen in Figure 9 A. A CBCT of the same tooth (Figure 9 B) shows that the distance to the pulp is under 0.6 mm in some places.

One month after the bio-mechanical preparation with Brix 3000®, the vitality of tooth 24 was preserved. After four years, preserved and intact pulp tissue without changes in the periodontium and the adjacent sinus is visible on the CBCT (Figure 10). Due to anatomical features, the apex of tooth 24 is adjacent to the maxillary sinus.

Figure 10. CBCT of tooth 24 after four years of biological treatment. The dental pulp, periodontium, and maxillary sinus integrity are preserved.

With CBCT, an investigation has established that the distance to the pulp was about 0.6 mm. Using the method of chemical-mechanical removal of infected dentin with papain gel, we did not have direct communication with the pulp.

Conclusion

Today, published literature confirms that the preparation is harmless, non-irritating, and non-damaging to healthy tissues in the oral cavity. Brix 3000® successfully removes infected dentin without affecting the affected one in the carious lesion. This is fully in line with the modern concept of minimally invasive dentistry. The lack of pain, overheating, vibration, and noise, and the biological and gentle action towards the dental pulp when applying to make it an indispensable assistant to the dentist in children and adolescents, as well as in adult patients.

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