

Pediatric Endodontics

Current Concepts in
Pulp Therapy for Primary and
Young Permanent Teeth

Anna B. Fuks
Benjamin Peretz
Editors



Springer

Pediatric Endodontics

Anna B. Fuks • Benjamin Peretz
Editors

Pediatric Endodontics

Current Concepts in Pulp Therapy
for Primary and Young Permanent Teeth

 Springer

Editors

Anna B. Fuks
Department of Pediatric Dentistry
The Hebrew University Hadassah
School of Dental Medicine
Jerusalem
Israel

Benjamin Peretz
Department of Pediatric Dentistry
The Maurice and Gabriela Goldschleger
School of Dental Medicine
Tel Aviv University
Tel Aviv
Israel

ISBN 978-3-319-27551-2

ISBN 978-3-319-27553-6 (eBook)

DOI 10.1007/978-3-319-27553-6

Library of Congress Control Number: 2016933125

Springer Cham Heidelberg New York Dordrecht London

© Springer International Publishing Switzerland 2016

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Printed on acid-free paper

Springer International Publishing AG Switzerland is part of Springer Science+Business Media
(www.springer.com)

*This book is dedicated to
Moises Fuks, my beloved husband and
long-term companion and friend
and to
Tamar, Neta and Alona Peretz, my beloved
and precious family*
Anna B. Fuks and Benjamin Peretz

Preface

The initial idea for writing this book came because we felt that there has been an explosion of scientific knowledge on the understanding of the pulp tissue in the last two decades, which, in turn, affect the proper treatment for various pulp pathological conditions. This immense advancement has included the primary pulp also, and pediatric dentistry today, with regard to pulp treatment, can provide a better, more problem-oriented therapy and treatment to the affected primary pulp. Therefore, when we were approached by the Springer representative to write this book, we gladly agreed.

We felt that there was a need for students, undergraduate and postgraduate alike, as well as for the professional community to be familiarized with the current “state of the art” on pediatric endodontics. We made all efforts to cover the various aspects of the dentin-pulp complex in pediatric dentistry: from the understanding of biological concepts of the healthy pulp, through the pulp reactions to the deleterious effects of caries, to the various treatment modalities for each type of pulp injury, to the adverse reactions to various pulp dressing materials, and to the postoperative prognosis.

The better understanding of these topics led us to conclude that a conservative approach in the treatment of reversibly inflamed pulp needs to be emphasized. Thus, considerable attention has been given to the conservative approach to pulp treatment in primary and young permanent teeth. Our message stresses the paradigm shift toward conservative treatment modalities, relying on an accurate diagnosis based on signs and symptoms to assess the appropriateness of the technique for a specific case.

Notwithstanding, the traditional modes of treatment are also covered.

Understanding the new concepts regarding pulp treatment will guide practicing pediatric dentists and general dentists to select the proper mode of treatment.

A special emphasis has also been given to the future of pulp treatment, in light of the innovative knowledge on stem cells. At present, there is a consensus that the future of medicine and dentistry, particularly of pulp treatment, lies in the thorough research on stem cells.

We hope that this text will be useful to all students and dentists who treat children, to provide a better care for their teeth.

Jerusalem, Israel
Tel Aviv, Israel

Anna B. Fuks
Benjamin Peretz

Contents

1 Pediatric Endodontics: Past and Present Perspectives and Future Directions	1
Anna B. Fuks and Benjamin Peretz	
2 The Primary Pulp: Developmental and Biomedical Background	7
Anna B. Fuks, Josimeri Hebling, and Carlos Alberto de Souza Costa	
3 Clinical Pulpal Diagnosis	23
Marcio Guelmann	
4 Indirect Pulp Treatment, Direct Pulp Capping, and Stepwise Caries Excavation	37
James A. Coll	
5 Pulpotomy Techniques: Cervical (Traditional) and Partial	51
Kaaren G. Vargas, Anna B. Fuks, and Benjamin Peretz	
6 Pulpectomy and Root Canal Treatment (RCT) in Primary Teeth: Techniques and Materials	71
Moti Moskovitz and Nili Tickotsky	
7 Restoration of Pulp-Treated Teeth	103
Kevin J. Donly and Jungyi Alexis Liu	
8 Pulp Therapy for the Young Permanent Dentition	117
Eyal Nuni	
9 The Future: Stem Cells and Biological Approaches for Pulp Regeneration	149
Jacques E. Nör and Carolina Cucco	
Index	163

Pediatric Endodontics: Past and Present Perspectives and Future Directions

1

Anna B. Fuks and Benjamin Peretz

Contents

1.1 Pediatric Endodontics	2
1.2 Historical Perspective	3
1.3 The Scope of the Book.....	3
1.4 The Aim of the Book	4
References.....	5

Dentistry for children is one of the most needed of all specialties in dentistry. Yet, unawareness of newer concepts of present-day pediatric dentistry practice and the ultimate goals to be achieved still exist. The value of teaching pediatric dentistry cannot be overestimated as inadequate or unsatisfactory dental treatment during childhood may damage permanently the entire masticatory apparatus, leaving the individual with many of the dental problems so common in today's adult population [1].

The utmost goals of modern pediatric dentistry are to bring children into the permanent dentition after natural exfoliation of their healthy and/or properly treated primary teeth and instill a positive attitude toward keeping habits of optimal dental and oral health.

A.B. Fuks, DDS (✉)
Department of Pediatric Dentistry, The Hebrew University
Hadassah School of Dental Medicine, Jerusalem, 12272, Israel
e-mail: fuks@mail.huji.ac.il

B. Peretz, DMD
Department of Pediatric Dentistry, The Maurice and Gabriela
Goldschleger School of Dental Medicine, Tel Aviv, Israel
e-mail: bperetz@post.tau.ac.il

1.1 Pediatric Endodontics

Pediatric dentistry is a unique specialty that deals with the total and comprehensive oral health care of children. As such, it involves all aspects of oral care ranging from prevention to restorative treatments. Historically, pediatric dentistry has evolved from an extraction-oriented practice at the beginning, where primary teeth with inflamed pulps were mostly extracted, and no focus has been put on preserving the pulp, to a specialty based on emphasizing prevention of oral and dental diseases.

A more conservative approach has been developed during the last decades regarding dental caries and specific modes of treatment such as minimal invasive dentistry and an increase use of prevention materials (mainly containing fluoride). This approach has been attributed to both developed diagnostic criteria and tools and to the new dental products and materials in the market. This approach goes further with regard to pulp therapy. It has long been established that the human dental pulp has a remarkable potential for self-healing when encountering a severe insult, especially in young patients, mainly due to the high degree of cellularity and vascularity. Incomplete caries removal, stepwise excavation, and indirect pulp treatment have been proposed to treat reversibly inflamed pulps. In addition, several techniques for managing irreversibly inflamed or necrotic pulps have been introduced in pediatric dentistry practice. Exposure of the pulp may occasionally be due to caries but may also occur by accident during cavity preparation or by fracture of the crown of the permanent maxillary incisors in particular.

Despite the extensive progress that has been achieved in prevention of dental caries worldwide, and the variety of treatment modalities to treat inflamed and/or infected pulp, a remarkable number of complications of untreated or poorly treated primary teeth and/or young immature permanent teeth are still encountered. This demands exact diagnosis, thorough knowledge of pulpal conditions and therapies, and also the value of the individual tooth for the occlusal development. Hence, pediatric endodontics has its own characteristics and includes the pulpal treatment of primary and young immature permanent teeth. It must always be seen in the total context of the dentition and the patient.

A review of the anatomy of primary teeth readily explains the frequent need for pulp therapy in these teeth. Specifically, Finn [1] and Ash [2] described twelve basic differences between primary and permanent teeth that can be summarized as follows: the enamel is thinner on primary teeth than on permanent teeth, and the thickness of the dentin between the pulp chambers and the enamel in primary teeth is less than in permanent teeth. The pulp, therefore, is correspondingly closer to the outer surface, and dental caries can progress and penetrate into the dentin more rapidly, leaving the tooth more susceptible to infection. Thus, pulp exposures caused by caries occur more frequently in primary teeth. If infection spreads to the alveolar bone, the developing permanent tooth may also be affected.

Pulp treatment of young permanent teeth must take into consideration the life expectancy of the young patient and provide the best conditions for the roots to develop and mature.

The practitioner should be familiar with the different treatment approaches to be able to select the most appropriate modality for each specific clinical situation.

1.2 Historical Perspective

The first method of capping exposed pulps was described by Phillip Pfaff, a dentist at the court of the Prussian King Friedrich II in Berlin in 1756 who used gold foils [3]. Several agents for direct pulp capping have been recommended ever since. The assumption that the pulp tissue must be irritated by cauterization in order to heal prevailed until the end of the nineteenth century, and most materials were used empirically. At the beginning of the twentieth century, it became obvious that microorganisms were the reason for pulp inflammation, and more attention was drawn to disinfecting agents that, although effective, were very cytotoxic. The lack of proper tools for achieving accurate diagnoses led to insufficient assessment of the pulp status leading to incorrect treatment selection. Thus, due to this fact, necrotic pulps were sometimes capped [3].

The first scientific clinical study to compare different capping materials was made by Dätwyler in 1921, whereupon zinc oxide-eugenol showed the best results. One year later, Rebel performed the first animal experiments with disastrous results, so he regarded the exposed pulp as a doomed organ. In 1920, Hermann introduced calcium hydroxide for root canal fillings. Between 1928 and 1930 he studied the reaction of vital pulp tissue to calcium hydroxide to prove that it was a biocompatible material. Since then, calcium hydroxide has been recommended by several authors for direct pulp capping, but it was only in the middle of the twentieth century was it regarded as the standard of care [3].

A Shift in the Paradigm of Treating Pulpally Involved Teeth

A change in clinical approach to pulpally involved teeth in pediatric patients will be proposed in this book and will be described in the different chapters. The change in approach involves a shift in the traditional paradigm regarding reversibly inflamed pulp from an “aggressive” approach involving total excavation of the carious dentin and the danger of exposing the pulp, towards a more “conservative” approach in which caries may be left in the pulpal wall to prevent pulp exposure. This approach is being slowly spread in the dental profession, and may become the treatment of choice for deep caries in modern pediatric dentistry practice.

As long as minimal invasive dentistry is still reluctantly accepted by the professional community many teeth with reversible pulp inflammation, that could otherwise be conservatively treated, will become pulpally involved. These teeth will be treated by the different pulp treatment modalities that will be described in this book.

1.3 The Scope of the Book

The nine chapters of this book will describe in detail the developmental and biomedical aspects of the primary pulp and comprehensive clinical diagnosis of the pulp leading to conservative approaches of pulp therapy, including stepwise excavation, indirect pulp treatment (IPT), and direct pulp capping. In the chapter on stepwise excavation and IPT, the Hall technique is mentioned. This technique, which

includes cementation of a stainless steel crown on primary teeth without any caries removal or tooth preparation, has been shown to be successful in several clinical studies [4]. As this technique contradicts all established accepted principles of good clinical practice and it is still unknown what is the long-term effect on the development of the occlusion, the Hall technique is definitely a proof that after an accurate diagnosis, caries can be left on a tooth if properly sealed.

Furthermore, even though our message emphasizes the shift toward conservative approaches, these rely on an accurate diagnosis based on signs and symptoms to check the appropriateness of the technique for a specific case. Evidently, a thorough radiographic evaluation is essential for proper diagnosis. Thus, when a conservative approach is not indicated, the pulpotomy technique, as old as it is (over 40 years), will be presented, and the various dressing materials will be critically discussed. In addition, the nature of successful treatment and, more importantly, failures will be described.

Following the chapter on pulpotomy, an extensive and detailed chapter on pulpectomy and root canal filling (RCT) will be presented, describing in detail the rationale behind RCT, the techniques to perform RCT, the instruments, and the associated materials. Again, the success and failure rates of RCT will be described.

A special chapter will be dedicated to the importance of appropriate restorations of pulpally treated teeth, emphasizing the need of leakage prevention to improve the final prognosis.

Although this book is mainly dedicated to primary teeth, as previously mentioned, children often present pulp pathology in their immature permanent teeth. These teeth deserve a different treatment approach than the permanent teeth in adults, and for this reason, a special chapter dealing with this subject is included.

Finally, innovative experimental biological treatment modalities such as using stem cells, a new and developing area in medicine and in dentistry, will be presented. This approach will no doubt be one of the most prevailing treatment modalities in the future. It will expand the scope of conservative treatments, giving the clinician a more versatile arsenal of tools to deal with the damaged pulp.

1.4 The Aim of the Book

This book is aimed to familiarize dental students as well as general practitioners and pediatric dentists with the different treatment modalities and complications of uncontrolled caries, offering them the tools to diagnose the degree of pulp inflammation and thus select the most appropriate treatment.

This book is meant to be a tribute to Dr. Sidney B. Finn, one of the pioneers in pediatric dentistry and mentor of one of the editors (ABF). Dr. Finn's nice and warm personality, showing always a humane and empathic attitude toward the patients and parents, had a tremendous influence on Dr. Fuks's education and professional formation.

References

1. Finn SB. The children's dentist, his practice and his community. In: Finn SB, editor. *Clinical Pedodontics*. 4th ed. Clinical Pedodontics, Philadelphia: WB Saunders; 1973.
2. Ash M. *Wheeler's dental anatomy, physiology and occlusion*. 7th ed. Philadelphia: WB Saunders; 1992.
3. Dammaschke T. The history of direct pulp capping. *J Hist Dent*. 2008;56(1):9–23.
4. Innes NP, Stewart M. The hall technique, a simplified method for placing stainless steel crowns on primary molars, may be as successful as traditionally placed crowns. *J Evid Based Dent Pract*. 2015;15(2):70–2.

The Primary Pulp: Developmental and Biomedical Background

2

Anna B. Fuks, Josimeri Hebling,
and Carlos Alberto de Souza Costa

Contents

2.1	Introduction.....	8
2.2	Formation of the Dentin–Pulp Complex.....	8
2.3	The Dental Pulp.....	12
2.3.1	Odontoblasts.....	13
2.4	Dentin Structure and Composition.....	14
2.4.1	Types of Dentin.....	14
2.5	Factors Affecting the Dentin–Pulp Complex Response to Stimuli in Primary Teeth.....	18
2.6	The Deleterious Effects of Bacterial Infiltration at the Restorative Material Margins.....	18
2.7	The Protective Role of the Remaining Dentin Thickness (RDT).....	19
2.8	Clinical Recommendations.....	21
	References.....	21

A.B. Fuks, DDS (✉)

Department of Pediatric Dentistry, The Hebrew University
Hadassah School of Dental Medicine, Jerusalem, 12272, Israel

e-mail: fuks@mail.huji.ac.il

J. Hebling, DDS, MS, PhD

Department of Orthodontics and Pediatric Dentistry, University Estadual
Paulista – UNESP, Araraquara School of Dentistry,

Rua Humaitá, 1.680 – Centro, Araraquara, SP 14.801-903, Brazil

e-mail: jhebling@foar.unesp.br

C.A. de Souza Costa, DDS, MS, PhD

Department of Physiology and Pathology, University Estadual Paulista – UNESP,
Araraquara School of Dentistry, Rua Humaitá, 1.680 – Centro,

Araraquara, SP 14.801-903, Brazil

e-mail: casouzac@foar.unesp.br

© Springer International Publishing Switzerland 2016

A.B. Fuks, B. Peretz (eds.), *Pediatric Endodontics: Current Concepts in Pulp
Therapy for Primary and Young Permanent Teeth*,

DOI 10.1007/978-3-319-27553-6_2

2.1 Introduction

Maintaining the integrity and health of the oral tissues is the primary objective of pulp treatment. Premature loss of primary teeth can lead to malocclusion and/or to esthetic, phonetic, or functional problems. It is important to attempt to preserve pulp vitality whenever possible; however, when this is not feasible, the pulp can be entirely extirpated without significantly compromising the function of the tooth [1, 2].

For more than one century, several conservative pulp therapies have been employed empirically, with no scientific evidence. From the early 1970s, several clinical and laboratory studies started to appear in the literature, leading to the development of therapeutic methods based on experimental techniques [3].

Tziafas [4] reported that the current knowledge concerning the molecular and cellular mechanisms that take place during tooth development stresses the similarities between the developmental and regenerative tissue events. The author suggested that the most important challenge in dentistry during the last two decades has been how to integrate the current concepts of biomedical research into the problem of preservation of tooth structure and function during dental treatment. He also claimed that the present knowledge of the biological mechanisms of tooth development and regeneration can provide opportunities to design new strategies or agents for the preservation of tooth structures and functions.

Since the pulp of a primary tooth is histologically similar to that of a permanent tooth, the purpose of this chapter is to familiarize the reader with the characteristics of the development, structure, and function of the dentin–pulp complex. This knowledge will serve as a basis for discussing the diagnosis of pulp pathologies and the healing potential of the dentin–pulp complex against different noxious stimuli, which will be discussed in future chapters.

2.2 Formation of the Dentin–Pulp Complex

The dental pulp is a specialized connective tissue of mesenchymal origin surrounded by tubular dentin walls occupying the pulp chamber and the root canal.

The specific group of pulp cells, known as odontoblasts, is responsible for the synthesis and deposition of the collagen-rich dentin organic matrix, which is further mineralized around the pulp tissue. Therefore, dentin and the pulp remain closely associated during development and throughout life and are commonly referred to as the dentin–pulp complex (Fig. 2.1a, b).

Events that take place on the dentin reverberate to the pulp and vice versa [5].

The dentin–pulp complex is surrounded on the crown by dental enamel and on the root by cementum, periodontal ligament, and bone. The harmony of the complex is impaired if the surrounding tissues suffer some kind of injury that can reach the pulp by the root canal or through the dentinal tubules [5].

Although the tooth is a unique organ, the principles that guide its development are shared in common with other organs such as lung, kidney, heart, mammary

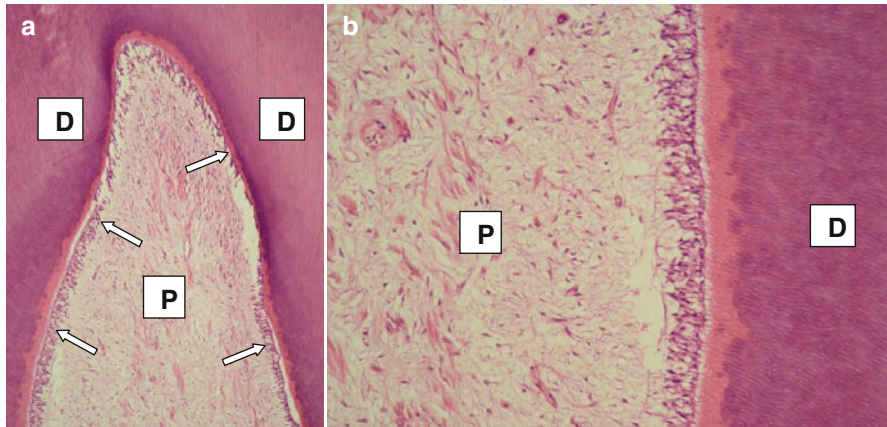


Fig. 2.1 (a) Histological section obtained from sound primary teeth. The tubular dentin (*D*) was synthesized and deposited by the odontoblasts (*arrows*), which are organized in a defined layer of cells that remains underlying this mineralized tissue. H/E, 32× (*P* Pulp). (b) High magnification of the (a). Note the continuous layer of odontoblasts beneath the thin layer of predentin. The subjacent pulp tissue (*P*) exhibits a number of cells, capillaries, and a loose extracellular matrix. H/E, 160× (*D* dentin)

glands, and hair follicles [6]. The most important developmental events are those guiding epithelial–mesenchymal interactions, which are characterized by a molecular cross talk between two tissues of different origins, the ectoderm and the mesenchyme [6].

Different stages of tooth development have been recognized at a microscopic level by their histologic appearance and were classically described as the dental lamina, bud, cap, and the early and late bell stages. In the modern literature, a functional terminology has been used to describe odontogenesis into four phases: initiation, morphogenesis, cell differentiation (cytodifferentiation), and matrix apposition [6]. The dental lamina is the first sign of tooth development. At the *lamina stage*, cells of the dental epithelium and those of the underlying ectomesenchyme divide at different rates and continue to grow and thicken to form a bud [6]. At the *bud stage*, cells of the ectomesenchyme proliferate and condense to give rise to the dental papilla. These cells have increased ability to proliferate, mobilize, and differentiate.

The *morphogenetic phase* involves the stages of bud, cap, and initial bell phase. During this period, a number of ectomesenchymal cells adjacent to the epithelium increase inside the ectomesenchyme, producing the site of origin of the dental papilla and of the dental follicle. These will develop into the dentin–pulp complex and into the support tissues of the tooth, respectively [6]. The formation of the enamel knot, during the transition from bud to cap, marks the beginning of crown formation. The cells of the enamel knot do not grow and serve as a signal for the cuspid formation pattern, influencing the form of the crown and the development of the dental papilla [6].