Laser-Assisted Pediatric Dentistry

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Core Message

The progress of laser application in dentistry is continuous. There are many debates between researchers, clinicians, and scientists who try to carry on research within and with respect to clinical everyday dental practice. The American Academy of Pediatric Dentistry acknowledges using lasers as scientifically documented, alternative, and/or adjunctive treatment provision methods of soft and hard tissue management for infants, children, adolescents, and persons with disabilities. The aim of this chapter is to describe the indications for their use in various therapeutic procedures in pediatric dentistry and to analyze the advantages and disadvantages compared to traditional techniques. Together with the appropriate child's psychological management, proper presentation and approach with the laser is crucial. The technological evolution of dental lasers offers the possibility of completing several therapeutic procedures, such as removing carious dental tissue in permanent and deciduous teeth, usually with less or no anesthesia, performing laser-assisted pulpotomy and pulpectomy, soft tissue interventions, dental trauma, etc. Depending on the treatment procedure and the targeted chromophores, all laser wavelengths could be used (e.g. KTP, diodes, Nd:YAG, erbium family lasers, CO_2).

11.1 Laser-Assisted Pediatric Dentistry

Pediatric dentistry is a demanding part of dentistry because of its nature to deal with children from birth through adolescence as well as with their parents' compliance. It requires from the clinician a high level of knowledge regarding the stomatognathic system conformation, the special anatomical figures, and the prevention, cure, and the prognosis of dental pathologies found in children, but above all, it requires expertise in treating the child itself. Pediatric dentistry practitioners are not only responsible for providing and promoting good oral and dental health for their patients but also to educate parents that oral health is an integral part of general health with continuous informative sources.

In general, the occurrence of oral diseases in children and adolescents includes dental caries, periodontal diseases (mainly in the form of gingival inflammation), developmental disturbances (morphological or numerical variations in both permanent and deciduous dentition), erosions, malocclusions, cranio-mandibular disorders, oral mucosal lesions (mainly aphthous ulcers, herpes simplex and other virus infections, or oral candidiasis), and, of course, dental trauma [1]. Over the past few years, traditional dentistry has been innovated with the embracement of more microinvasive techniques, moving from the era of «extension for prevention» to «prevention for extension» model of modern dentistry. In this technological-dental evolution with micro-abrasion, the application of topical fluoride, the use of sealants, and the general adhesives techniques, laser technology has started to become more popular to the pediatric dental world. The widespread use of lasers in dentistry can be employed for both diagnosis and treatment and as stated by the American Academy of Pediatric Dentistry (AAPD): «the use of lasers is an alternative and complementary method of providing soft and hard tissue dental procedures for infants, children, adolescents, and persons with special health care needs» [2].

11.2 Behavior Management and Laser Application

Dental specialists are trained to diagnose and treat dental diseases according to evidence-based dentistry with the behavior guidance to be the priority of the dental treatment. The dental practitioner interacts with the patient and their parents and through that procedure identifies appropriate or not behaviors, understands the emotional state of each person, and promotes empathy and compassion. The goal is to achieve communication, eliminating dental fear and anxiety in order to build a circle of trust between the child, the parent, the dentist, and the dental staff.

Earning child/parent's trust before managing to achieve high patient cooperation is the ultimate issue in pediatric dentistry. This is a difficult and demanding task, because many children perceive a visit to the dentist as stressful. This is an expected reaction, since an appointment includes several stress-evoking components, such as strange sounds and tastes, having to lie down, meeting unfamiliar adult people and authority figures, discomfort, and even pain. Even though laser therapy sounds promising and well accepted by the parents due to the possibility of better therapeutic results for their children and the assumption of no pain treatment (anesthesia may be necessary), the use by the dentist of the new technology still requires a degree of compliance by the child patient. Although a dental practice may have several modern and friendly devices, it remains an unknown and peculiar environment for the young child and may provoke negative emotions and stress during child's first visit. Therefore, the practitioner should choose and offer dental treatment with the appropriate methods and instruments that are suitable for each patient. Sometimes laser treatment is preferable, especially for young children who refused the traditional dental treatment (◘ Fig. 11.1a–e). Laser treatment can be used to introduce dentistry, gain the trust of the child, and perform needle-free and also no painful procedures. Through this, oral laser applications may also offer an alternative strategy in behavior management (◘ Fig. 11.2a–g). A positive experience during dental treatment is of paramount significance for a lifelong confiding relationship between the child and the dentist, which may also lead to better oral health in the adulthood.

Either way, for its successfulness and the child's acceptance, a well-prepared presentation, training, and education on that have to be proceeded before the use. The pediatric

Fig. 11.1 **a**–**e** Resin-modified glass ionomer (RMGI) restorations on the primary second molars, without the use of local anesthesia, of a 3-year-old uncooperative girl with primary molar hypomineralization (PMH). **a** Preoperative intraoral view. According to the traditional treatment recommendations, stainless steel crowns (SSC) should be placed on teeth #75 and 85 under local anesthesia. **b** Laser analgesia (starting with 50 mJ, 10 Hz, 82% water (16 ml/min), 70% air, distance 6 to 10 mm from the tooth, for 40 to 60 s, and continuing with 80 to 100 mJ for 60 more seconds before tooth preparation) and cavity preparation (see Table 11.2 for energy parameters) by Er,Cr:YSGG (2780 nm, gold handpiece, 0.6 mm MZ tip, H tissue mode). **c** After laser preparation. The cavity was well extended into dentin. The child revealed no pain and no complain and cooperation was relatively good. **d** Final RMGI restoration. **e** Intraoral view 24 months after treatment. Restorations are still in place and there are no caries lesions. The patient is now 5 years old and cooperative, and it is the practitioner's decision if and when he/she will provide a more permanent rehabilitation

dentist may use some of the basic behavior techniques to introduce laser to the child. One of the most powerful techniques is «tell, show, do» in which the practitioner explains verbally the consecutive stages of the dental treatment (tell), demonstrates the equipment and shows the different tools/instruments on the hand/finger (show), and executes the procedure (do) [3]. Laser technology can be introduced using friendly, familiar, and easy-to-understand words like «special flashlight», «magic light», «colored light», etc. The sound of the laser could be like «making popcorn», «playing metal music», etc. The special glasses are going to make you look like «a ninja», «a princess», etc. In conjunction with the technique «tell, show, do» positive reinforcement (e.g. use of phrases like «great job» or a reward at the end of the session) and distraction techniques (e.g. television, movies, music) should be adopted. Children who do not cooperate or the mental status does not allow them to comply cannot be candidates for laser therapy.

11.3 Local Anesthesia and Laser Application

Local anesthesia is the basis in controlling pain during dental treatment, but, at the same time, one of the most common and major fears for the patient. Traditionally most of the dental treatment procedures need to be performed under local anesthesia. Laser analgesia provides an extra tool for the dentist to avoid or reduce the use of local anesthesia, in some cases. It should be stated that analgesia is not really anesthesia, but a way to reduce sensitivity, needing a more intensive stimulus for the patient to feel pain. Studies using infrared wavelengths (diode, Nd:YAG) conclude that low-level energy doses (LLLT) can suppress the excitation of unmediated C-fiber afferents of the pulp. Also, there are studies regarding the potential analgesic effect of erbium family lasers irradiation and the mechanism resulting in this effect. Many clinicians report that they have been successful in performing a variety of dental procedures, in pediatric dentistry too [4, 5].

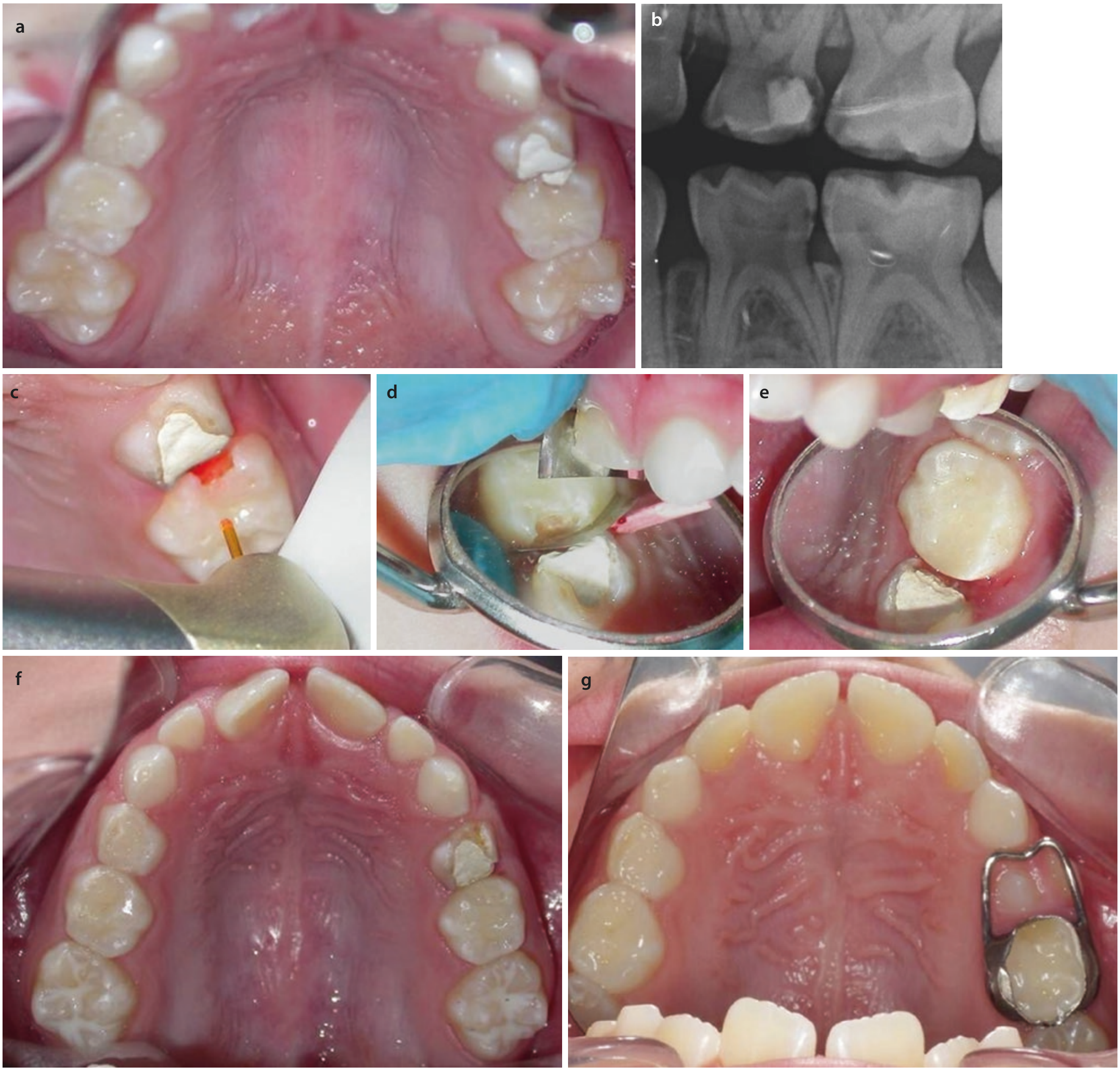

Fig. 11.2 **a**–**g** Behavior shaping using laser for the completion of dental treatment of a referred 7.5-year-old needle-phobic girl with low cooperation at the dental office. Laser treatment is used to introduce dentistry, gain the trust of the child, perform needle-free and also no painful procedures, and «desensitize» the patient through gradual exposure to dental treatment: perform first sealants, needle-free restorations (laser analgesia and preparation), and finally the extraction. **a** Initial intraoral view of the upper arch. **b** Left bite wing radiograph. Tooth #64 had to be extracted due to abscess and root resorption. Note that caries was well extended into dentin on #65. **c** Cavity preparation on #65 (see Table 11.2 for energy parameters). No local anesthesia but laser analgesia (see text and Fig. 11.1b for laser parameters) and preparation by Er,Cr:YSGG (2780 nm, gold handpiece, 0.6 mm MZ tip, H tissue mode). **d** After laser preparation of #65. The child revealed no pain and no complain and cooperation was good. **e** After RMGI placement on #65. **f** Intraoral view of the upper arch after 2 months. The patient presented for extraction of tooth #64 with the administration of local anesthesia (4% articaine, 1:200,000 epinephrine). Cooperation was excellent. **g** After 20 months. The permanent successor is erupting and space maintenance has to be removed. Restoration on #65 remains intact

In all clinical cases presenting in this section, laser analgesia was applied using the Er,Cr:YSGG (2780 nm) laser with the following parameters: starting with 50 mJ, 10 Hz, (0.5 W), 82% water (16 ml/min), 70% air, distance 6 to 10 mm from the tooth, for 40 to 60 s, and continuing with 80 to 100 mJ for 60 more seconds before tooth preparation (gold handpiece, 0.6 mm MZ tip, H tissue mode) (Figs. 11.1a–e, 11.2a–g, and 11.3a–d). There are no studies reporting any analgesic effect of CO_2 wavelength. Theoretically, the ideal laser wavelength choice would be the one that has an analgesic effect and that can be used in all of those treatment procedures at the same time.

Fig. 11.3 a–d Minimal gingivoplasty and subgingival composite resin restoration, in a single visit and without administration of local anesthesia, on tooth #83 of a 7-year-old boy. **a** Initial clinical view. Placement for 3 min only EMLA cream (lidocaine 2.5% and prilocaine 2.5%) on dry gingiva. **b** Minimal gingivoplasty using Er,Cr:YSGG (2780 nm) at 50 mJ, 20 Hz, (1.0 W), 30% water (6 ml/min), 70% air, tip distance 1 mm (close contact), tip parallel to the long axis of the tooth (gold handpiece, 0.6 mm MZ tip, H tissue mode). **c** After gingivoplasty and cavity preparation by Er,Cr:YSGG (2780 nm) (see Table 11.2 for energy parameters). **d** Final composite resin restoration

The performance of laser analgesia using erbium family lasers could be a useful tool to overcome behavioral problems, especially for needle-phobic children seeking dental treatment (Fig. 11.2a–g). Also, only the application of topical anesthetic gel on dry gingival or mucosa for 3–5 min [e.g. EMLA cream (lidocaine 2.5% and prilocaine 2.5%, each gram of EMLA cream contains 25 mg lidocaine and 25 mg prilocaine)], without the administration of injected local anesthesia, is efficient in performing minimal gingival interventions in several clinical cases by erbium family lasers (Figs. 11.3a–d and 11.4a–f).

It should be noticed that a prerequisite for achieving cooperation with the child and complete dental treatment is the minimization of disturbance and the absence of pain. Completion of dental treatment with children is directly related to the absence of pain. There is always a possibility of pain during dental treatment after laser analgesia, and, in this case, laser energy parameters should be altered, or local anesthesia should be delivered. Adult patients can communicate their feelings with the dentist and may tolerate the pain to some extent and to remain cooperative, but children are frightened, lose trust to the dentist when their teeth ache, and then do not cooperate. It is the dentist's responsibility, after evaluating the child's maturity and providing adequate psychological preparation to reach a high degree of cooperation, to decide if local anesthesia should be administered before laser-assisted dental treatment. In general, if there is a possibility of pain, it is preferable to deliver local anesthesia before the start rather than during the dental treatment in children with low cooperation. Examples of such cases are shown at Figs. 11.5a–e and 11.7a–i. These patients were not cooperative (one had extremely high gagging reflex which is very often associated to «hidden» dental anxiety). Laser analgesia could be used but it was decided that block anesthesia was more appropriate for these patients.

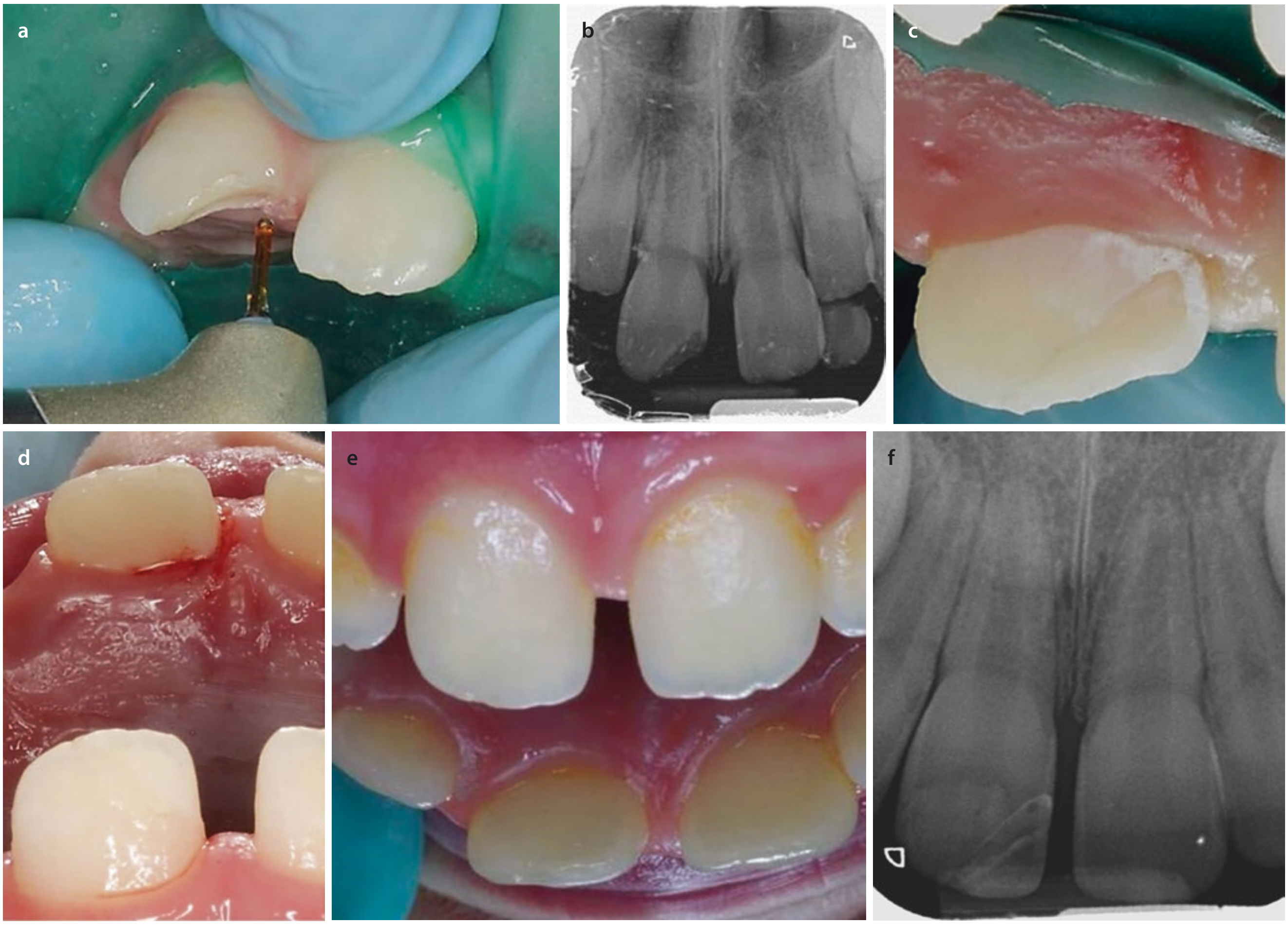

Fig. 11.4 **a**–**f** Minimal gingivoplasty using Er,Cr:YSGG and reattachment of tooth fragment, in a single visit and without local anesthesia, following enamel-dentine subgingival (no pulp involvement) crown fracture on a permanent incisor of a 7.5-year-old boy. **a** Rubber dam placement, EMLA cream (lidocaine 2.5% and prilocaine 2.5%) for 3 min. Minimal gingivoplasty using Er,Cr:YSGG (2780 nm) (see laser energy parameters on Fig. 11.3b). **b** Initial radiographic image (no complete root formation). **c** After minimal gingivoplasty and before tooth fragment reattachment using composite resin. There is no gingival bleeding and tooth structures have been exposed. **d** Final restoration. **e** and **f** Clinical and radiographic views 30 months after treatment showing root formation

11.4 Types of Lasers Used in Pediatric Dentistry

Caries management includes prevention (fluoride application, dietary instructions, everyday oral hygiene), detection, and treatment management. Treatment includes the removal of the infected dental tissue, the cavity preparation, and, depending on the case severity, indirect or direct pulp capping, pulpotomy, and pulpectomy, followed by tooth restoration. At this time, erbium family lasers are the ones that can be commonly used on both hard tissues, for caries removal and cavity preparation, and soft tissues too. The targeted chromophore for this wavelength is primarily water and secondarily hydroxyapatite. This, and in combination with the mid-infrared wavelength (less penetrative compared to shorter wavelengths), results in its superficial effect on tissues, minimizing the risk for collateral thermal damage. The remaining laser wavelengths can be used successfully on the rest of the procedures, especially regarding hemostasis achievement in pulp or gingiva before restoration and decontamination, since the targeted chromophore in soft tissues is hemoglobin and melanin (for KTP, diodes, and Nd:YAG), with respect to their more penetrative wavelength (except for the CO_2 which, due to its longer wavelength and high absorption in water, is the less penetrative of all) [6]. Regarding caries prevention, CO_2, erbium family lasers, and Nd:YAG (due to their high power values emitted and ability to photothermally melt enamel) have been tested alone or in combination with fluoride, especially through in vitro studies. Infrared irradiation (diode lasers), due to its high penetration (and low absorption on hard tissue), is used widely in detecting caries.

Periodontal diseases in children usually include minimal-severity gingivitis infections, usually due to poor everyday oral hygiene, and hyperplastic gingivitis with the formation of pseudo-pockets (not completely erupted teeth). In

Fig. 11.5 **a**–**e** Minimal gingivoplasty and treatment of subgingival caries, in a single visit, on teeth #83, 84, and 85 after preparation by Er,Cr:YSGG (2780 nm) of a 7.5-year-old girl. Also treatment of occlusal caries on #46. **a** Intraoral initial clinical view. **b** and **c** Block anesthesia (4% articaine, 1:200,000 epinephrine) and placement of rubber dam. Using Er,Cr:YSGG (2780 nm), [1] remove caries from #46 (enamel 4 W, 20 Hz, (200mj) 82% (16 ml/min) H_2O, 70% air) (RC restoration and sealant) [2]. Minimal gingivoplasty on teeth #83, 84, and 85 (see laser energy parameters on Fig. 11.3b) and [3] caries removal from teeth #83, 84, and 85 (see Table 11.2 for energy parameters for primary teeth). **d** Placement of SSC on #84 and #85 and buccal RMGI restoration on #83. **e** Clinical view after 26 months. The girl is almost 10 years old; #83 is movable and #84 has been normally exfoliated. Restoration on #83 is intact

addition, gingival and periodontal changes may be seen during or following orthodontic treatment, due to difficulties in maintaining good oral hygiene and/or the periodontal tissues following the teeth movement during the orthodontic treatment. All laser wavelengths can be used in these instances, for laser decontamination, and, if needed, removal of hyperplastic gingival tissue.

Apart from tooth decay, tooth injuries represent the most frequent pathology encountered in pediatric dentistry. Around 20% of children suffer a traumatic injury to their primary teeth and over 15% to their permanent teeth [7]. Dental trauma is a stressful and challenging emergency situation for the child, the parents, and the dentist. Accurate diagnosis in combination with immediate intervention is required, so that any risk of sequel problems or healing complications is minimized. Mid-infrared wavelength lasers could be used to reduce acute pain, to improve and speed up tissue healing (photobiostimulation effect), to provide decontamination and inflammation control, and to help control bleeding.

Among the other advantages, the use of lasers can often make it easier for the dentist to perform several procedures in the same appointment (Figs. 11.3a–d, 11.4a–f, 11.5a–e, and 11.7a–i).

11.5 Restorations on Primary Teeth

Dental caries is one of the most common diseases in childhood, and several well-established restorative methods and materials have been used for replacing the carious dental tissues of primary teeth. Lasers can be used as alternative instruments to completely or partly substitute traditional instruments and techniques or to help and contribute to traditional dental treatment. The erbium family lasers are used for caries removal and cavity preparation on primary teeth. Enamel and dentine in primary teeth have compositional and structural differences from those of permanent teeth. Primary tooth enamel is less mineralized and more porous, and prisms do not have an orderly spatial organization. Primary tooth dentine has more water, less in number, and narrower dentinal tubules. Therefore, lower laser energy parameters than those for permanent teeth should be used for caries removal and cavity preparation on primary teeth (Tables 11.1 and 11.2). Water flow is given both in percentage and ml/min. The percentage of water given means the percentage of the maximum possible amount of water the specific laser unit could provide. For example, 70% (7 out of 10) for Fotona LightWalker (Er:YAG, 2940 nm) is water flow of 32 ml/min, while 82% for Er,Cr:YSGG (Waterlase MD, 2.780 nm) is 16 ml/min.

All dental restorative materials [composite resin (CR), compomers (C), resin-modified class ionomer (RMGI), glass ionomer (GI)] could be placed after laser cavity preparation on primary teeth (Figs. 11.1a–e, 11.3a–d, and 11.5a–e). There are no long-term randomized clinical trials about restoration of primary teeth using lasers. However, there are several studies concluding that laser abrasion is a safe and useful alternative method for caries removal and cavity preparation on primary teeth [8–11]. Studies on bond strength restorative materials after preparation of primary teeth by laser or traditional method showed lower or equal results [12–16]. The results on marginal microleakage are controversial but most of the studies report good results (similar or better than the diamond bur), for both laser wavelengths of the erbium family. The restorative materials studied include several types of CR, C, RMGI, and GI. In the case of CR and C, several etching (total etch, self-etch) and adhesive systems (one-step adhesive, two-step adhesive, self-etching adhesive) are studied [17–26]. Also, a study showed no statistical significant difference on marginal microleakage between Er:YAG and Er,Cr:YSGG lasers for any of CR, RMGI, and GI restorations [26]. The main advantages of laser use in restorative pediatric dentistry are patient and parent's acceptance, the administration of no or less local anesthesia, the absence of vibration, the cavity decontamination effect, and the selectivity of dental caries.

Table 11.1 Parameters for cavity preparation with Er:YAG laser (2940 nm) on primary teeth. Tip diameter 600 μm, 70% water (32 ml/min for Fotona LightWalker), 1 mm tip to tissue distance, (1) enamel preparation, (2) dentine preparation, (3) dentine finishing-conditioning and removal of dental caries, (4) enamel finishing-conditioning, and (5) decontamination (based on Professor Wayne Selting's laser parameter calculation sheet)

Energy per pulse (mJ)	Average power (watts)
1. 160–200 mJ, 10 pps	1. 1.6–2
2. 80–100 mJ, 10 pps	2. 0.8–1
3. 40–60 mJ, 10 pps	3. 0.4–0.6
4. 35–50 mJ, 20 pps	4. 0.70–1
5. 50 mJ, 20 pps, defocus for 15 s	5. 1

Table 11.2 Parameters for cavity preparation with Er,Cr:YSGG (Waterlase MD, 2.780nm) on primary teeth. Tip diameter 600 μm, 82% water (16 ml/min), 1 mm tip to tissue distance, (1) enamel preparation, (2) dentine preparation, (3) removal of dental caries, (4) dentine finishing-conditioning, (5) enamel finishing-conditioning, and (6) decontamination (based on Professor Wayne Selting's laser parameter calculation sheet)

Average power (watts)	Energy per pulse (mJ)
1. 2.0 W, 10 pps	1. 200
2. 1.5 W, 10 pps	2. 150
3. 1 W, 10 pps	3. 100
4. 0.5 W, 10 pps	4. 50
5. 0.75 W, 20 pps	5. 37.5
6. 1 W, 20 pps, defocus for 15 s	6. 50

11.6 Pulp Treatment in Primary Teeth

Pulp treatment in primary teeth is usually required due to deep dentine caries or dental trauma. Indirect pulp capping, direct pulp capping, and pulpotomy are the treatment options for vital teeth, while pulpectomy is the recommended treatment for necrotic or irreversible pulpitis in primary teeth. The treatment choice is based on well-known clinical and radiographic criteria: history of pain and signs or symptoms of pulp degeneration are indications of necrotic pulp or irreversible pulpitis [27]. The use of the erbium family laser is beneficial for cavity preparation, especially in cases of teeth with deep dentin caries, because of (a) the selective and minimal tooth structure removal aiming to avoid unnecessary mechanical pulp exposure and (b) the facility of dentine decontamination and smear layer removal (see Tables 11.1 and 11.2 for energy parameters). In many cases, no local anesthesia is required when erbium family lasers are used. In addition, for all the above reasons, when interim therapeutic restoration (ITR) [28] is the choice of contemporary treatment in order to prevent the progression of dental caries on uncooperative patients, the use of lasers could be beneficial.

11.6.1 Indirect Pulp Capping

The goal of the technique is to preserve the integrity of the vital pulp and also activate the repairing mechanism for the formation of tertiary dentine. All decayed enamel and dentine except the decayed dental tissue located next to the pulp has to be removed. The pulpal wall is covered with a biocompatible protective base (usually mineral trioxide aggregate (MTA) or Portland cement (PC) or biodentine or calcium hydroxide or glass ionomer), and the final restoration follows (glass ionomer restorative material or resin-modified glass ionomer or composite resin or preformed crowns). It has the same indications to pulpotomy on primary teeth [29], presenting success rates up to 83–100% using the traditional preparation techniques [30, 31], but there is no clinical study involving the use of laser at the indirect pulp capping on primary teeth. However, it is speculated that the laser-assisted technique (erbium family or/and near-infrared laser wavelengths) could be more predictable and successful due to decontamination of the cavity, the remaining carious dentine, and the positive effect on pulpal tissue healing and recovery [32]. See Tables 11.1 and 11.2 for laser wavelength parameters for deep dentine removal (erbium family) and decontamination.

11.6.2 Direct Pulp Capping

When the vital pulp is exposed because of mechanical caries removal or trauma, direct pulp capping could be performed. However, direct pulp capping is not recommended for primary teeth [27]. The success rate of the traditional techniques is 70–80%, using MTA or PC or biodentine or calcium hydroxide as pulp dressing material, while usually there is acute edema and pain after 7–15 days in case of failure [33]. Therefore, there is a general recommendation to avoid direct pulp capping in primary teeth and perform pulpotomy, in case of any size of pulp exposure [27, 33]. Successful laser-assisted direct pulp capping cases have been reported [32], but there is no clinical study involving the use of any laser wavelength in such a treatment on primary teeth. Following cavity preparation using a diamond bur or a laser from the erbium family, the laser-assisted technique (erbium family, diode, Nd:YAG, CO_2) is introducing pulp tissue coagulation (erbium family: 50 mJ, 10 Hz, no water, 40% air, defocus for 5–10 s) along with decontamination before the placement of pulp dressing [32]. After laser-assisted direct pulp capping, it is expected that better pulpal healing occurs than with the traditional technique; the pulp will retain its vitality and perform the formation of tertiary dentine. See Tables 11.1 and 11.2 for laser wavelength parameters for decontamination.

11.6.3 Pulpotomy

The traditional technique of pulpotomy has clinical success rates up to 98–100% [MTA/PC/biodentine or ferric sulfate (FS)] and is the most common technique performed after pulp exposure on vital primary teeth with deep carious dentine lesions. The technique involves the removal (amputation) of the coronal pulp tissue with burs and spoon excavator, achievement of hemostasis using sterile cotton pellets, and placement of MTA/PC/biodentine or FS over the pulp stumps [27]. When the bleeding from the pulp stumps could not be controlled, it is an indication of irreversible pulpitis beside the absence of clinical and radiographical symptoms, and pulpectomy is indicated. Formocresol had been used for several years (before the wide use of FS) with great success, but its use is not currently recommended due to possible carcinogenic effect. The MTA/PC/biodentine is covered by glass ionomer, while in the case of FS, a fast setting zinc oxide and eugenol paste (IRM) is placed over the pulp stumps before the placement of the final restoration. FS forms a ferric ion and protein complex on contact with blood, providing a bridge between the vital root canal pulp tissues, and the paste contains eugenol (IRM), while the biocompatible and also bioinductive MTA/PC/biodentine has to be in contact with the pulp tissue.

Alternatively, instead of using medicaments like FS, laser (erbium family, diode, Nd:YAG, CO_2) could be used for the pulp tissue coagulation over the pulp stumps before the placement of IRM (Fig. 11.6a–g). Clinical studies show that either there is no significant difference in success rate (clinical or radiographically) between laser-assisted and traditional pulpotomy, or the result is in favor for the laser-assisted method [34–41]. After coronal pulp was removed with burs and spoon excavator and hemorrhage was controlled, a type of laser [diode (five studies), Er:YAG (one study), Nd:YAG (one study), CO2 (one study)], using a variation in laser application parameters (power, frequency, exposure time) and capping materials (MTA, zinc oxide eugenol, IRM), reports success rate of laser-assisted pulpotomy (follow-up period from 1 to 66 months) which ranged from 71.4% to 100% clinically and 71.4% to 100% radiographically. The amputation through vaporization of the coronal pulp tissue using lasers (erbium family, diode, Nd:YAG, CO_2) is not recommended because they create coagulation and necrotic tissue which may camouflage possible inflammation or necrosis of the root canal pulp. See Tables 11.1 and 11.2 for laser wavelength parameters for decontamination (erbium family).

11.6.4 Pulpectomy

Pulpectomy is the endodontic treatment for primary teeth and is indicated for teeth without or with minimal pathological (internal or external) root resorption due to irreversible pulpitis or necrotic pulp. The traditional technique involves the removing of all coronal and root pulp tissue, limited mechanical instrumentation, root canal disinfection using the appropriate irrigants, and filling the root canals with resorbable material (pure zinc oxide-eugenol paste or iodoform-calcium hydroxide paste). Several protocols have been developed using lasers (erbium family, diode, Nd:YAG,) with great results for better decontamination of the main and the lateral canals on permanent teeth [42–46]. These same protocols for permanent teeth, using the same parameters, are also recommended for primary teeth but there are only four studies (one in vivo, one in vitro, and two case reports) for deciduous teeth, all using photodynamic therapy, leading to satisfactory results [47–50]. In addition to the traditional technique, a laser-assisted disinfection method could be performed before the final conclusion of the endodontic treatment (Fig. 11.7a–i). Laser-assisted disinfection could have better results on primary teeth where there are more complex, with variable morphology root canals making instrumentation and disinfection complicated. Irrigation with sodium hypochlorite should be avoided, especially when the laser-activated irrigation protocol is used, because if extruded from the open or resorbed root apex, it could be an irritant to the surrounding tissues.

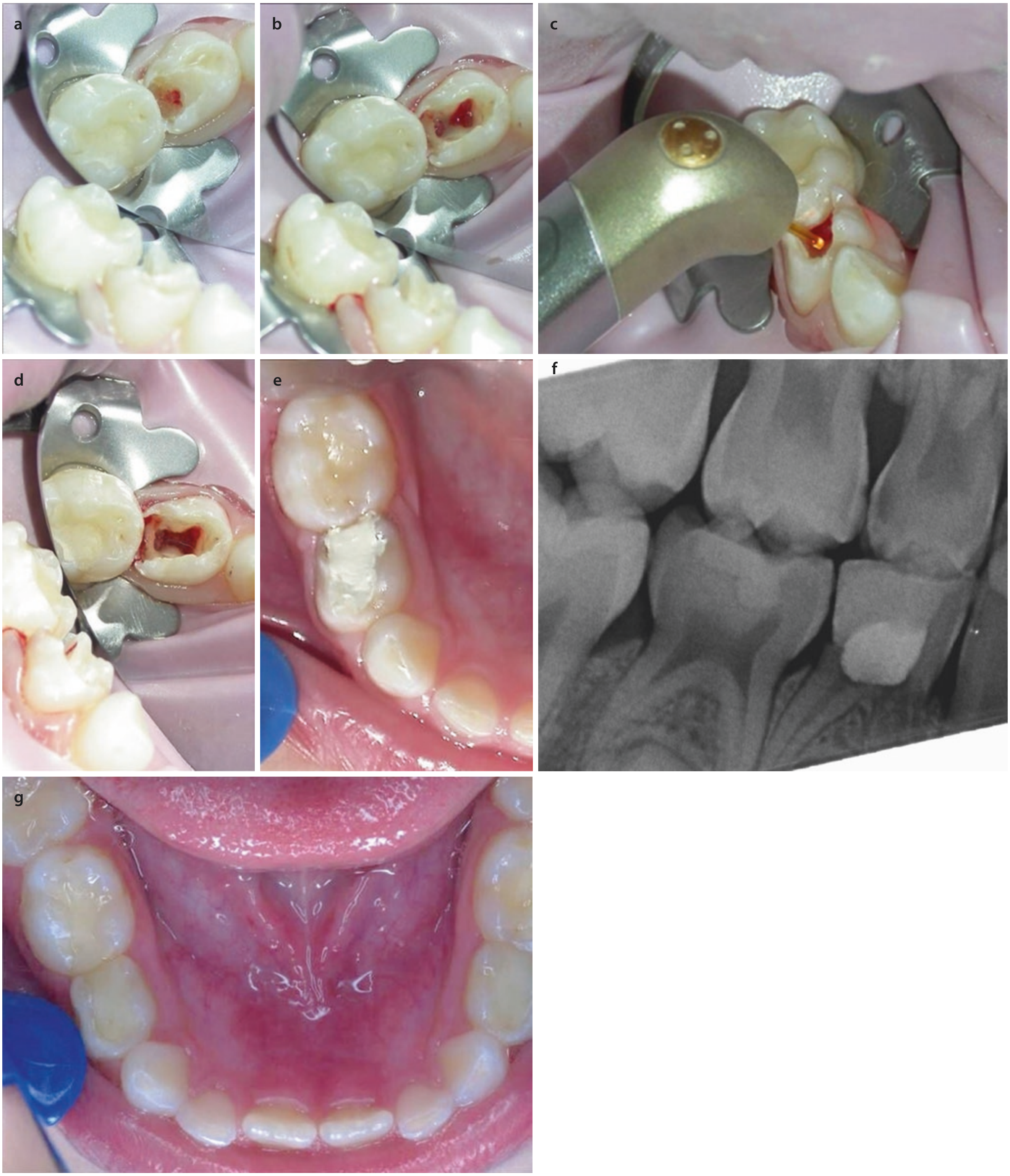

Fig. 11.6 **a**–**g** Laser-assisted pulpotomy on a first primary molar of a 5.5-year-old girl. Block anesthesia (4% articaine, 1:200,000 epinephrine) and placement of rubber dam. **a** Pulp exposure during caries removal. **b** Removal of the coronal pulp tissue (diamond bur and spoon excavator). Hemorrhage was controlled. **c** Er,Cr:YSGG (2.780 nm) was applied at 50 mJ, 10 Hz, (0.5 W), no water, 40% air; defocus for 5–10 s (gold handpiece, 0.6 mm MZ tip, S tissue mode) over the canal orifices. **d** Complete coagulation after laser application. **e** The cavity was filled up with IRM (fast setting zinc oxide and eugenol paste). Clinical view after 15 days. The placement of RMGI restoration was followed. **f** and **g** Radiographic and clinical pictures 16 months after treatment

◘ **Fig. 11.7** **a**–**i** Laser-assisted pulpectomy and gingivoplasty on a first primary molar of a 6.5-year-old boy. Endodontic therapy of #84 due to abscess. The patient returned 10 days after the initiation of treatment with a subgingival crown fracture. **a** Intraoral view of lower teeth. **b** Block anesthesia (4% articaine, 1:200,000 epinephrine) and placement of rubber dam. Occlusal view of #84. **c** Laser-activated irrigation (Er,Cr:YSGG 2.780 nm) was applied at 33 mJ, 30 Hz (1.0 W), no water, no air, tip inside the tooth chamber, saline solution for 5 s each root canal (gold handpiece, 0.6 mm MZ tip, H tissue mode). **d** Obstruction of the root canals with pure zinc oxide and eugenol paste and filling the tooth chamber with fast setting zinc oxide and eugenol paste (IRM). Gingivoplasty (see laser energy parameters on ◘ Fig. 11.3b) and cavity preparation followed (see ◘ Table 11.2 for energy parameters). **e** After gingivoplasty and cavity preparation and decontamination. **f** Final restoration with RMGI. **g** Pulpectomy and restoration after 3 months. SSC was placed on #84 at that visit. **h** and **i** Periapical radiograph and clinical views 16 months after treatment

Conclusion

All dental laser wavelengths (KTP, diode, Nd:YAG, erbium family, CO_2) could be used as alternative and/or complementary treatment methods of soft and hard tissue management for the pediatric dentistry patients. The main advantages of laser use in pediatric dentistry are (a) patient and parent's acceptance, (b) the administration of no or less local anesthesia, (c) the absence of vibration during cavity preparation, (d) the selectivity of dental caries, (e) the decontamination effect, and (f) making it easier for the dentist to perform several procedures in the same appointment. In addition to these advantages, the use of lasers can often offer an alternative strategy in children's behavior management along with the appropriate child's psychological management. Laser treatment can be used to introduce dentistry, gain the trust of the child, and perform needle-free and also no painful procedures using laser analgesia, especially for children who refused traditional dental treatment. However, children who do not finally cooperate or the mental status does not allow them to comply cannot be candidates for laser therapy.

Laser-assisted treatment in pediatric dentistry includes, among others, the removal of the infected dental tissue, the cavity preparation, and, depending on the case severity, indirect or direct pulp capping, pulpotomy, and pulpectomy, followed by tooth restoration. Several studies concluded that laser abrasion is a safe, useful, and highly accepted by patients alternative method for caries removal and cavity preparation on primary teeth (erbium family). All dental restorative materials (composite resin, compomers, resin-modified class ionomer, glass ionomer) could be placed after laser cavity preparation on primary teeth revealing high success. Laser-assisted indirect and direct pulp capping techniques for primary teeth (erbium family or/and near-infrared laser wavelengths) could be more predictable and successful, than the traditional techniques, due to decontamination of the cavity, the remaining dentine, and the positive effect on pulpal tissue healing and recovery in order to form tertiary dentine. Instead of using medicaments (like ferric sulfate) during primary teeth pulpotomy, laser (erbium family, diode, Nd:YAG, CO_2) could be used, with great clinical and radiographical success, for the pulp tissue coagulation over the pulp stumps before the placement of the fast setting zinc oxide and eugenol paste (IRM).

Laser-assisted disinfection, before the final root canal obstruction, could have better results on primary teeth pulpectomy where there are more complex, with variable morphology, root canals making instrumentation and disinfection complicated.

11

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