Restorative Management of Permanent Teeth Enamel Defects in Children and Adolescents

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Suzanne M. Hanlin, Lucy A.L. Burbridge, and Bernadette K. Drummond

Abstract

The clinical challenges associated with the restorative management of developmental defects of enamel (DDE) have been well documented and include managing sensitivity and caries risk, loss of occlusal determinants, and the negative impact on individual self-worth and social interaction. This chapter outlines management options for DDE associated with molar incisor hypomineralization (MIH), amelogenesis imperfecta (AI), fluorosis, and intrinsic discoloration in permanent teeth. Many materials and techniques may be used to manage DDE. The complexity of intervention is dictated by the severity and nature of the disturbances including color (brown/cream/yellow/white opacities – hypomineralization), structure (hypoplasia – pits, grooves), pre-eruptive resorption, post-eruptive breakdown, the patient's individual circumstances, and the age and stage of development.

S.M. Hanlin, BDS, MDS, GradDipHealInf
Department of Oral Rehabilitation, Faculty of Dentistry, University of Otago, PO Box 647, 9054 Dunedin, New Zealand
e-mail: suzanne.hanlin@otago.ac.nz

L.A.L. Burbridge, BDS DipConSed, MClinDent
Paediatric Dental Department, Newcastle Dental Hospital, Newcastle Upon Tyne NE2 4AZ, UK
e-mail: lucy.burbridge@nuth.nhs.uk

B.K. Drummond, BDS, MS, PhD (✉)
Department of Oral Sciences, Faculty of Dentistry, University of Otago, 310 Great King Street, PO Box 647, Dunedin 9054, New Zealand
e-mail: bernadette.drummond@otago.ac.nz

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Introduction

The aim of treatment for a child or adolescent with developmental defects of enamel (DDE) is to provide comfort, natural form, and function and prevent additional problems. Setting achievable goals is key to ensuring a successful outcome because the impact on perception of attractiveness and well-being can sometimes skew and heighten the expectations of children and families unrealistically [1]. Management and maintenance costs can be considerable and impact directly and indirectly on all members of a family. Extensive defects may be associated with other anomalies and the development of an interdisciplinary plan in early childhood is important to protect compromised tooth structure and establish occlusal stability [2]. Definitive management may not occur until late adolescence or early adulthood, and consideration must be given to the ability of children to manage treatment and avoid burnout. Clinicians must be responsive to the changing esthetic and functional needs of the developing child and adolescent.

Restorative modalities can include tooth bleaching and microabrasion therapy, enamel infiltration with composite resin [3], direct and indirect veneering materials and/or indirect (laboratory-fabricated or computer-aided design, CAD-milled) polymethyl methacrylate (PMMA), and composite or ceramic restorations. Full-coverage restorations may be required for more severely affected teeth where masking of the underlying tooth color is required, or there is severe sensitivity or a need to improve the shape of the tooth. Preformed stainless steel crowns (SSC) can be placed on affected permanent (as well as primary) molar teeth in childhood to maintain occlusal support and arch length [4]. The use of composite, acrylic, or polycarbonate shell crowns has also been reported [5, 6]. In late adolescence or early adulthood, these interim solutions may be replaced with laboratory-fabricated composite resin, ceramic, porcelain fused to metal (PFM), cast, or CAD-milled ceramic or alloy crowns.

Choosing Materials and Techniques for Bonding in Compromised Enamel

Because of the wide variation in the clinical presentation of enamel defects, recognition of the etiology and subsequent management can be difficult. However, differential diagnosis of the defect will assist in determining which treatment techniques and materials may perform best. It has been suggested that by understanding the origin of the enamel defect, clinicians are able to more appropriately target the treatment to the patient's needs, preserve residual tooth structure, and avoid overly invasive procedures [7]. Conventional enamel etching and bonding techniques following manufacturer's guidelines are usually successful for enamel that is reduced in quantity but still well mineralized (i.e., thin or hypoplastic). If dentine is relatively unaffected, dentine bonding systems, glass ionomer, polyacid-modified composite resins (PMCR), or resin-modified glass ionomer cements

(RMGIC) offer predictable bond strengths to dentine and improve restoration prognosis. Hypomineralized enamel and/or a defective dentinoenamel junction (DEJ) affects the restoration bond strength, and the enamel may shear off or detach. Hypocalcified enamel often results in increased wear rates and chipping. Hypomineralized enamel (containing more protein) exhibits significantly lower micro-shear bond strengths with predominantly cohesive fractures of restorations and enamel loss due to shallow etching patterns, a porous adhesive interface, and cracks in the enamel [8].

Approaches that have been investigated to improve bonding to defective enamel include modification of the acid used for etching (organic rather than inorganic), use of self-etching primers, glass ionomer cement sandwiches with composite, resin-modified glass ionomer cements (RMGIC), and pretreatment of enamel with 5 % sodium hypochlorite [9–15]. However to date, none of these approaches provide a predictable way of achieving adhesion to hypomineralized enamel. This remains a challenge for long-term restoration success and is probably the single most important factor that forces progression to full-coverage restorations in late adolescence or early adulthood.

Management of Enamel Defects in Anterior Teeth

Treatment of anterior teeth with enamel defects is usually initiated by patients because of dissatisfaction with their appearance. Improvement is important for psychosocial well-being particularly during the mixed and early permanent dentitions [16, 17] (See Chap. 7). During childhood, the least invasive approach necessary to meet the esthetic demands of each individual should be adopted. For every technique, pretreatment radiographs and tooth shades should be recorded at baseline against which changes can be assessed over the long term.

Microabrasion

Acid pumice microabrasion is a controlled method of removing surface enamel to reduce discolorations particularly when this is limited to superficial layers and to allow further mineralization. Microabrasion is achieved by a combination of abrasion and erosion ("abrosion") [18]. Approximately 100 μm of enamel is removed in one or two appointments. Any additional enamel removal has the potential to damage the pulp or can result in exposure of underlying dentine [19].

Indications

- Diffuse (superficial) and small demarcated enamel opacities
- Hypomineralized enamel defects
- Post-orthodontic treatment decalcification
- Initial treatment for demarcated enamel opacities

Contraindications
- Deep hypoplastic enamel defects
- Intrinsic discolorations, e.g., tetracycline (dentinal) discoloration
- Discoloration associated with nonvital teeth

Technique
- Clean teeth with pumice and water to remove superficial staining and plaque and expose a clean enamel surface, wash, and dry.
- Isolate the teeth with dental dam. Mix 18 % hydrochloric acid (HCl) with pumice into a slurry or use acid from a proprietary kit. Apply a small amount to the labial surfaces using a rubber cup rotating slowly (5–10 s). Wash carefully into an aspirator tip. Repeat until the stain has reduced, up to a maximum of 60-s acid exposure. Remove the dam and apply color-free neutral fluoride.
- The patient should apply either fluoride gel- or a calcium-based material (CCP–ACP, calcium triphosphate) several times a day until follow-up to enhance remineralization.
- Review 2–4 weeks later, repeat once more if clinically indicated, and if not, consider an alternative treatment modality. Repeat sensibility tests and update photographs.

Outcome

It is important to give detailed preoperative explanation to establish realistic expectations. Delay final review for at least 1 month as the appearance of the teeth will continue to improve over this time [20]. The best outcomes are achieved in cases of brown mottling that are more easily masked than more opaque white lesions and even white mottling becomes less perceptible (Fig. 11.1a, b). Improvement has been attributed to the relatively prismless layer of compacted surface enamel produced by the "abrosion" technique which alters the optical properties of the tooth surface [18]. No associations between microabrasion and pulpal damage, increased caries susceptibility, or prolonged thermal sensitivity have been reported. The technique is straightforward and not time-consuming to perform for the operator or patient. Microabrasion may assist with masking of a lesion in preparation for later composite restorations or veneers. This technique can be used in conjunction with bleaching agents with good outcomes [21] and can reduce the impact of the yellow hue or lighten other staining further [22, 23].

Bleaching

A bleaching agent (e.g., 10 % carbamide peroxide) can be applied to the surfaces of teeth with the aim being to lighten color. The exact mechanism of bleaching is unknown, but the release of hydrogen peroxide anions, reactive oxygen molecules, and free radicals is thought to be involved in lightening the stained mineral and

Fig. 11.1 (**a**, **b**) Change in enamel on permanent upper incisors following two microabrasion treatments with ongoing use of CPP-ACP with fluoride

protein in the enamel. Discoloration can reoccur because of a combination of chemical reduction of the previously formed oxidation products, marginal leakage of restorations allowing ingress of bacterial and chemical by-products, salivary or tissue fluid contamination, or food color contamination via the permeable tooth structure.

Indications

- Hypomineralized enamel defects
- Mild tetracycline staining
- Mild fluorosis

Contraindications

- Hypoplastic enamel defects

Techniques

- Vital bleaching can occur chairside/in the office or at home using custom-designed bleaching trays (vacuum formed).
- The in-office technique involves application of carbamide peroxide to the surfaces of the teeth with activation of the process by a heat source. This consumes chair time, adding to the expense. It is useful for treatment of mild enamel defects where strict isolation of a single tooth is required.

- The home bleaching technique utilizes a custom bleaching tray constructed for the maxillary and/or the mandibular teeth. The patient applies the carbamide peroxide (gel) to the teeth via the tray on a daily basis until the desired color change is achieved. There are many proprietary products available, and the principal differences lie in the concentration of carbamide peroxide employed and the amount of hydrogen peroxide released. Current recommendations indicate that a 10 % solution is both safe and successful in modifying tooth color.
- The concurrent use of a calcium-based product such as that with casein phosphopeptide–amorphous calcium phosphate will control any tooth sensitivity.
- Review 2–6 weeks later. An 80 % color change should have occurred.
- Take postoperative photographs including the pre- and posttreatment shade tab for long-term records.

Outcome

Minor ulceration or irritation may occur during the initial treatment which may relate to tray overextension. There may be transient pulpal sensitivity because carbamide peroxide gel (10 %) breaks down in the mouth into 3 % hydrogen peroxide and 7 % urea. Both have low molecular weights that allow them to diffuse through enamel and dentine and cause pulp irritation [24]. If sensitivity occurs, exposure time can be decreased, or it may be necessary to discontinue treatment. To date, there is no evidence that bleaching solutions with a low pH (below the critical pH of 5.2–5.8) causes enamel demineralization [25], possibly because urea, followed by ammonia and carbon dioxide, is released on degradation of the carbamide peroxide elevating the pH. Bond strength of composite resin to bleached enamel decreases initially and has been attributed to the residual oxygen in the bleached tooth surface inhibiting polymerization of the composite resin, but this returns to normal within 7 days [26]. Vital-bleaching systems do not modify the color of restorative materials and any perceived effect is probably due to superficial cleansing. Regular retreatment may be necessary to maintain effective lightening [27]. When considering the use of bleaching products, the clinicians should be mindful of local regulations and seek advice with respect to contemporary legislation.

Direct Restoration with Composite Resin

Composite resin bonded to etched enamel and/or pretreated dentine can be used to restore tooth defects or improve esthetics by replacing or masking areas of discolored or defective enamel.

Indications
- Demarcated enamel opacities
- Hypoplastic enamel defects

Contraindications
- Diffuse enamel opacities

Technique

- Apply dental dam and contoured matrix strips if required.
- Selective removal of demarcated lesion with a round diamond bur may be required to optimize esthetics and bonding; however, bonding can also be improved by selective use of GIC, or polyacid-modified composite.
- The enamel margins can be chamfered with a diamond fissure bur to increase the surface area for retention and blend the composite margin with the enamel.
- Etch the area, wash and dry, and apply the primer, bonding agent, and the chosen shade of composite. A brush lubricated with bonding agent can be used to smooth and shape before light curing.
- Remove the matrix strip/dam, polish with graded polishing discs and diamond finishing burs, and characterize the surface if required.
- Take postoperative photographs for records.

Outcomes

Restoration of localized hypomineralized or hypoplastic defects using composite resin is not usually associated with sensitivity and may not need local anesthesia unless there is caries with extension into dentine. These very conservative resin-bonded restorations are particularly suited to newly erupted incisors (Fig. 11.2a, b).

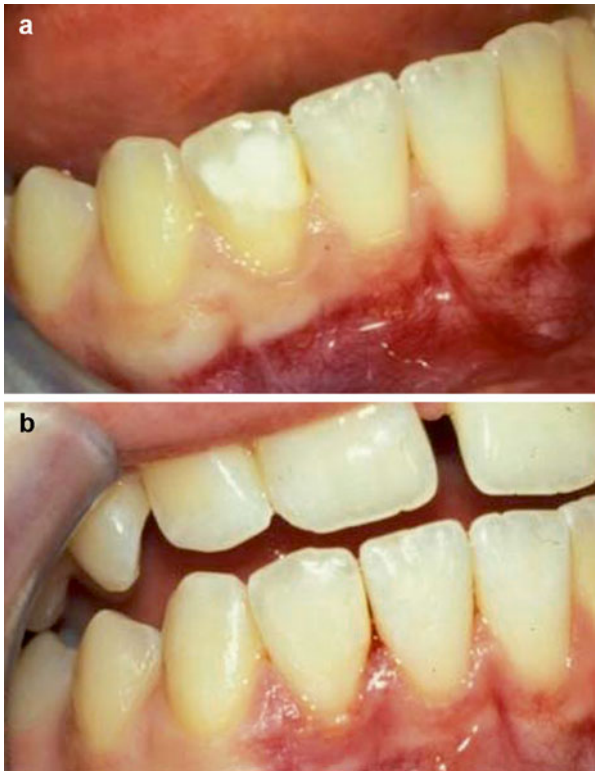

Fig. 11.2 (**a**, **b**) Lesion on the lower right lateral incisor masked with composite resin

However, when it is not possible or desirable to remove the entire opacity, problems with marginal staining, color matching, and suboptimal esthetics can arise.

Composite Resin Veneers

Composite resin can be used as a veneer to cover the entire labial aspect of the tooth and improve color and contour. These veneers can also protect against further breakdown of severely hypoplastic enamel as shown in Fig. 11.3a, b. Composite veneers may be directly placed at the chairside or indirectly fabricated in the laboratory. Composite veneering is conservative, cost-effective, and repairable in the mouth and may offer a satisfactory long-term alternative to full-coverage restoration in mild enamel defects even in adults. They are useful in the young dentition, in immature teeth with large pulp horns, large pulp chambers, immature gingival contour, and short crown height on teeth that are still erupting.

Before proceeding with any veneering technique, it is necessary to decide whether to reduce the thickness of labial enamel. Increased labio-palatal bulk without tooth preparation makes it harder to maintain good oral hygiene. However, increase in the labial contour may enhance appearance of in-standing or rotated

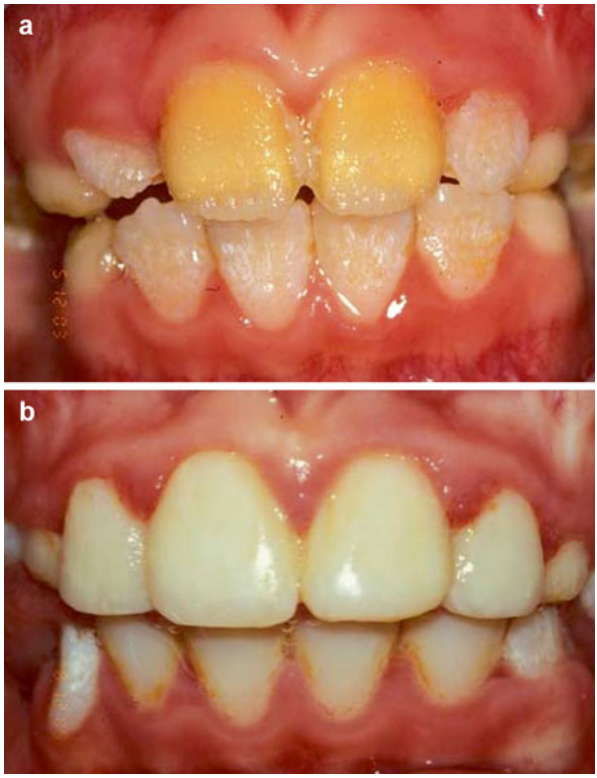

Fig. 11.3 (**a**, **b**) Resin veneers for upper incisors in the early mixed dentition period

teeth. Bond strengths to enamel are increased when 200–300 μm of the surface enamel is removed, and the restoration will maintain the tooth contour. Some reduction and/or use of an opaquing agent may be required to mask intense stain in a discolored tooth. Hybrid composite resins finished to a higher surface luster can replace relatively large amounts of missing tooth tissue or may be used in thin sections. Layering of dentine and enamel shades can be used to simulate natural color gradations and hues.

Indications
- Large demarcated enamel opacities
- Widespread hypoplastic enamel defects

Contraindications
- Very darkly discolored teeth
- Minimal enamel defects
- Insufficient tooth tissue available for bonding
- Oral habits, e.g., woodwind musicians where embrasure may be critical
- Heavy occlusal load/parafunction

Technique: Direct Composite Veneers
- Use a tapered diamond or sharp tungsten carbide bur to reduce labial enamel by 0.3–0.5 mm if required. Identify a finish line at the gingival margin and extend mesially and distally just labial to the contact points.
- Clean with a slurry of pumice in water, wash, and dry to remove plaque and debris.
- Isolate the tooth with dam and a contoured matrix strip if needed.
- Etch enamel, wash, and dry. Apply a thin layer of primer and bond with a brush and use an opaquing agent at this stage if discoloration is intense.
- Apply composite resin and shape. Light cure according to manufacturer's instructions at the gingival margin and the mesio-incisal, disto-incisal, and palatal aspects if incisal coverage has been used. Different shades can be combined to achieve matches with adjacent teeth and transition from a relatively darker gingival area to a lighter more translucent incisal region.
- Finish the margins with diamond finishing burs and interproximal strips and the labial surface with graded finishing discs.
- Take postoperative photographs for records.

Outcome

Good esthetics can be maintained for many years with regular reviews and repolishing as needed [28]. Indirect composite veneers can be fabricated from elastomeric impressions of the teeth, direct scanning of the prepared tooth or indirect scanning of a stone working cast. Laboratory-fabricated composite veneers can provide many of the characteristics of a ceramic veneer as described below. Color reproduction

and surface wear are improving. However, in a situation with high esthetic demand, porcelain would still be the material of choice for restoration longevity and stability.

Porcelain Veneers

Porcelain has superior esthetic properties to composite resin, improved resistance to abrasion, and is well tolerated by gingival tissues. However, porcelain requires tooth preparation to maximize fit and maintain tooth contour and to allow replication of color. Disadvantages are that it is not repairable in the mouth and the laboratory stages add to cost when compared to directly placed restorations. Best outcomes are obtained after teeth have erupted completely, and therefore these restorations should generally be delayed until late adolescence (ideally after 20 years of age). Further information about preparation and design are covered in prosthodontic textbooks.

Restorative Management of Enamel Defects in Posterior Teeth

Clinicians face challenges when attempting to cover posterior teeth that are partially erupted, have significant sensitivity, suffer post-eruptive breakdown, or are difficult to anesthetize. Recommendations for managing sensitivity are included in Chap. 9. Where it is not appropriate to seal enamel because of the degree of hypomineralization, longer-term solutions are required.

Planning and Trialing the Occlusal Scheme

Patients with isolated teeth affected by enamel defects may have stable intra- (tooth to tooth) and inter-arch (maxilla to mandible) contacts, and acceptable arch alignment and length that provide a functional occlusion. Restorative management can be undertaken while conforming to the existing occlusal scheme. Where there is significant hypoplasia of the occlusal surfaces of molars and premolars, the teeth may not erupt into contact or the occlusal contacts that are formed may be on unstable inclined planes that predispose to tooth movement and tooth chipping. Specific malocclusions are associated with some types of AI including anterior open bite, delayed eruption, and/or missing teeth [29]. In such cases, a reorganized occlusal scheme has to be planned, and the vertical dimension, tooth replacement and repositioning, restorative materials, and techniques all have to be taken in to consideration in order to achieve long-term occlusal stability. Creation of the final occlusal interface requires a restorative solution, but arch alignment, uncovering teeth and preservation of arch length, requires orthodontic and sometimes surgical management to support the restorative plan. Compromises in the ideal plan may often occur with successful management requiring ongoing explanation and discussion with patients and parents.

Where enamel defects are minimal and the teeth have areas of normal enamel, composite resin may be placed on the occlusal surfaces taking care to overlap the

bonded margins onto healthy enamel. Preformed stainless steel crowns placed over the tooth with minimal or no preparation provide a very useful intermediate option in the younger child. Before the permanent dentition has erupted, children usually manage well if "bite opening" occurs when crowns are placed. However, care should be taken when there is an existing anterior open bite. In adolescents, other options such as PMMA resin crowns or Zirconia-milled crowns are being trialed where esthetics may be of particular concern.

Stainless Steel Crowns

Stainless steel crowns have proved to be a very successful solution to preserve posterior molars with developmental defects or other defects during childhood and adolescence until an appropriate time to place more permanent restorations.

Indications
- Hypomineralized molars with breakdown or sensitivity
- Hypoplastic molars
- To prevent further tooth wear

Contraindications
- Severely broken down tooth that cannot retain the crown.
- Extraction and orthodontic management is preferred.

Technique with Tooth Preparation
- Provide local anesthesia and systemic analgesia if required for very sensitive teeth.
- Minimally reduce the mesial, distal, and occlusal surfaces with a fine tapered diamond
- Select and fit the appropriate crown. The crown height may need to be reduced, crimped, and polished to place the margin just at the gingival margin of the tooth [30].
- Check the occlusion, remove the crown, fill with a GIC-based cement, and replace other tooth. Have the patient bite on gauze to seat the crown firmly. Remove excess cement. Interproximal cement can be removed with floss with several knots that is pulled through under the contact point.

Technique with No Tooth Preparation
- If possible, place orthodontic separating elastics a few days before treatment.
- Select the appropriate crown and adjust the height if required. Crimp the crown and seat to check the margin.
- Check the occlusion, remove the crown, fill with an appropriate cement, and replace on the tooth. Have the patient bite on gauze to seat the crown firmly. Remove excess cement. Interproximal cement can be removed with floss with several knots pulled through under the contact point.

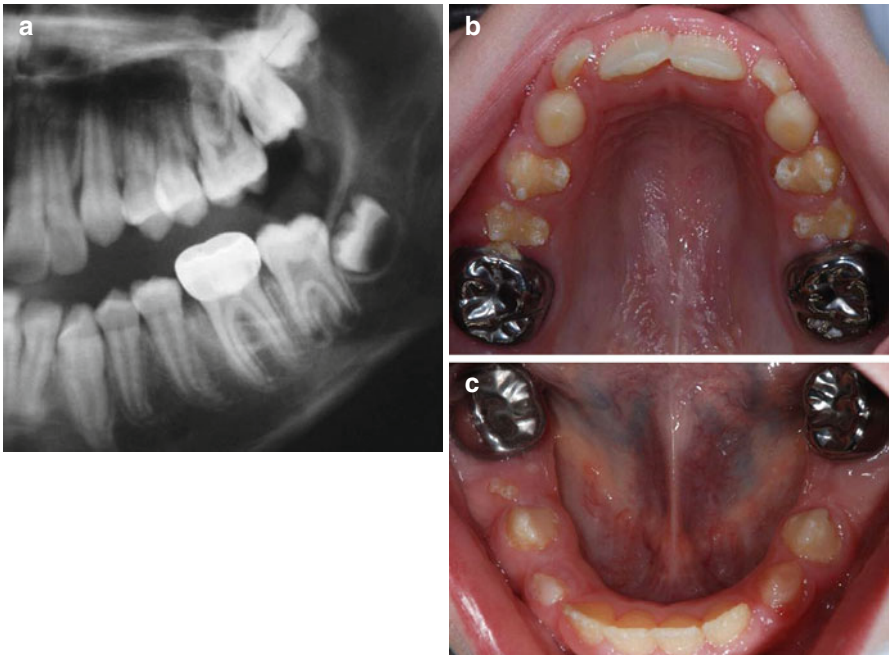

Fig. 11.4 (**a**) Radiographic appearance of appearance of a stainless steel crown on a lower left first molar with DDE. (**b**, **c**) Stainless steel crowns placed on severely hypoplastic molars in AI. Note the hypoplasia of the rest of the erupting permanent teeth

Outcome

Stainless steel crowns seal the teeth and provide thermal protection allowing the pulps to mature. The enamel is protected from breakdown, the occlusion is maintained, and the teeth can continue to erupt to the mature height, thus providing optimal conditions for more definitive solutions in late adolescence or adulthood [4]. This is illustrated in Fig. 11.4a–c.

Periodontal Management: Gingival Recontouring and Crown Lengthening

Adolescents with gingival enlargement, delayed or failed eruption of teeth or impacted teeth, and missing teeth may require surgical intervention such as gingival recontouring, crown lengthening, or surgical exposure prior to restoration. These can be done using traditional surgical approaches and/or with soft tissue laser surgery which is associated with improved tissue healing and reduced postoperative discomfort [31]. Figure 11.5a–c demonstrates the increase in available enamel that can be created following gingival recontouring in an adolescent with hypoplastic

Fig. 11.5 (**a–c**) Post crown lengthening surgery in maxillary and mandibular right and left quadrants showing access to good quality enamel in hypoplastic AI

AI. The extent of the defects and number of teeth will determine if periodontal management can be undertaken with local anesthetic alone or will require sedation or general anesthesia. A team approach involving a pediatric dentist, prosthodontist, periodontist, and orthodontist is important to optimize care. Good explanation of the short- and long-term goals will help children and their parents understand the reasons for surgery and the restorative plan.

Indirect Interim Restorations

Laboratory-fabricated composite resin (CR) crowns, CAD-milled PMMA, or CR provisional crowns constructed from scans of the dentition may be resilient interim restorations during adolescence. Premolar teeth can also be restored with directly or indirectly fabricated composite onlay restorations or with complete coronal recontouring determined by the extent of the enamel defects. Pretreatment diagnostic wax-up of the desired tooth form and contacts is useful in planning for this. Teeth affected by AI may have a rim of less affected enamel at or just below the gingival cuff, and once uncovered this provides a satisfactory finish line, requiring minimal additional tooth preparation for indirectly fabricated restorations (onlays/overlays or crowns). This is illustrated in Fig. 11.6a–c.

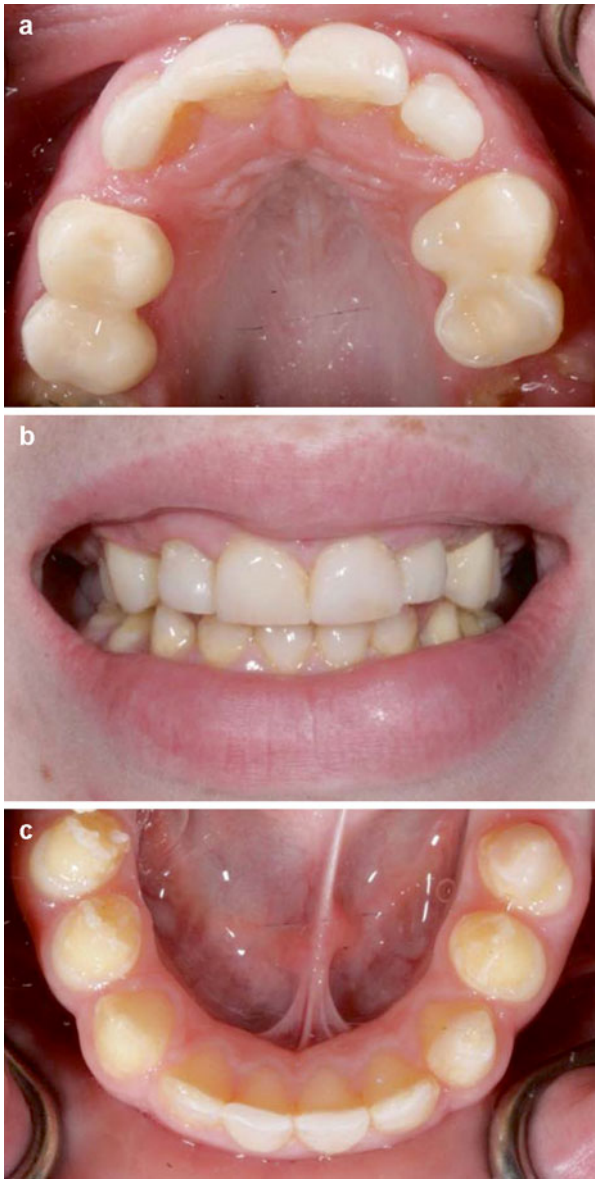

Fig. 11.6 (**a**–**c**) Interim PMMA provisional crowns (splinted on posterior teeth) and directly built composite resin onlays on anterior teeth in preparation for laboratory-fabricated composite resin crowns to provide protection and functional form during orthodontic management. Note missing 13 and 23 failure of eruption

Partial Veneers/Occlusal Overlays and Crowns

Veneers, overlays, or crowns restore missing tooth tissue by surrounding part or all of the remaining natural structure [32]. They restore form, function, esthetics, and longevity and provide protection. They are indicated for teeth with large occlusal

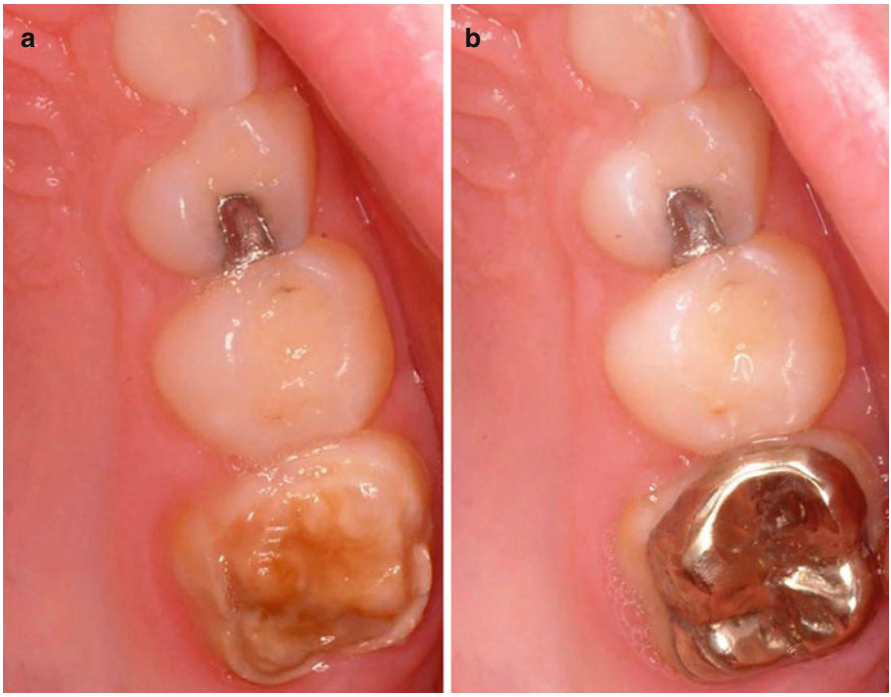

Fig. 11.7 (**a**, **b**) Pre- and post-placement of a preformed gold onlay, cemented on unprepared upper first molar using Panavia Ex

defects and are well described in restorative dentistry textbooks. Limitations include patients who are unable to cooperate for the procedure, financial constraints, compromised pulpal or periodontal prognosis, or lack of adequate supporting dentine. Veneers, overlays, or crowns may be preformed, laboratory fabricated or generated by CAD–CAM technology in either the clinic or laboratory. Many materials are available or in development and include non-precious alloys, acrylic, composite resin, ceramic, porcelain fused to metal, and gold (Fig. 11.7a, b).

Outcomes

The outcomes are dependent on the exactness of the procedures and the quality and quantity of underlying dentine [33]. These restorations require ongoing maintenance and monitoring and eventual replacement during adulthood. The primary goal in late childhood and adolescence should be to restore the teeth as effectively as possible to preserve tissue for subsequent restorations.

Conclusion

It can be very difficult for practitioners to decide how best to restore newly erupted permanent teeth that have hypomineralized or hypoplastic enamel. The primary aim is to protect the teeth from further breakdown and caries and to minimize sensitivity. In the anterior region, it is also important to address esthetic concerns. The second aim is to protect the pulp to allow normal maturation so that teeth will be permanently restorable in early adulthood. These goals are achievable using a combination of adhesive resin materials and preformed crowns including stainless steel crowns. These restorations can provide protection for up to 10 years during which time the developing occlusion can be managed in a multidisciplinary manner involving dentists, pediatric dentists, orthodontists, and prosthodontists. However, all this care is not without considerable cooperation from the child/young person. Practitioners should focus on providing the best interim solutions in the most acceptable way to the child and their family which may include accessing sedation and/or general anesthesia in addition to local anesthetic.

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