Top tips for restoration of root-filled teeth: Part 1 – minimally invasive techniques for anterior teeth

By R. J. R. Smith,[1] E. McColl[2] and G. E. Bryce[3]

Trauma to anterior teeth is a common cause of pulp necrosis, and subsequent requirement for root canal treatment (RCT). Pulp pathosis in such teeth is usually mediated via bacterial ingress through cracks/fractures +/- damage to the blood supply of the tooth. In such cases, the bulk of tooth tissue may be relatively intact (though often discoloured to some extent). In this paper, we offer advice for restorative management of such teeth, via minimally invasive techniques.

1. Assessment

a. Prior to (re)restoration of a root-filled tooth, clinical and radiographic assessment should determine: the restorability of the tooth, nature of any discolouration, technical quality of the root filling, periapical health, and presence of root fractures or resorption lesions. We advocate the removal of all restorative materials as part of the restorability assessment.

b. When clinical or radiographic signs/symptoms of non-resolving endodontic pathology or the root filling is technically sub-optimal (eg voids or does not extend to within 2 mm of the radiographic apex[1]), then root canal re-treatment +/- referral to a specialist endodontist is advised prior to bleaching (if required) and definitive restoration. Figures 1 and 2 demonstrate a previously traumatised 21 with a large periapical radiolucency and the subsequent endodontic and restorative management.

2. Discolouration

a. Root-treated teeth can be discoloured due to one or more intrinsic or extrinsic mechanisms;[2] some of the most common ones are outlined in Table 1.

b. Partial or complete calcification of the root canals (eg calcific metamorphosis) has a reported incidence of 4–24% following dental trauma.[3] The crowns of affected teeth classically have a yellow hue, and root canal calcification can be confirmed radiographically. Pulp testing in such teeth is unreliable,[4] which can complicate decision-making. RCT is not indicated unless there are clear clinical or radiographic signs of pulpal pathosis; for instance, pain or periapical radiolucency. The appearance of both vital and non-vital teeth with calcific metamorphosis can generally be improved with bleaching, although the regime may need to be continued for up to three months to effect a discernible change. If vital bleaching is unsuccessful, then the aesthetics of the tooth can often be improved via minimal tooth preparation and provision of a low-translucency opacious porcelain veneer (see section 5).

3. Non-vital bleaching

a. Root-filled teeth, discoloured via organic pigment staining, are amenable to non-vital bleaching. Prior to definitive restoration, bleaching can be delivered either via an internal ('walking-bleach') approach (eg sealing bleach into the pulp chamber), or a combined internal/external approach (eg bleach is placed into the pulp chamber, as well as a custom-made bleaching tray).

b. Historically, 35% hydrogen peroxide was commonly used for bleaching non-vital teeth in conjunction with the walking-bleach technique. However, since 2012, the maximum

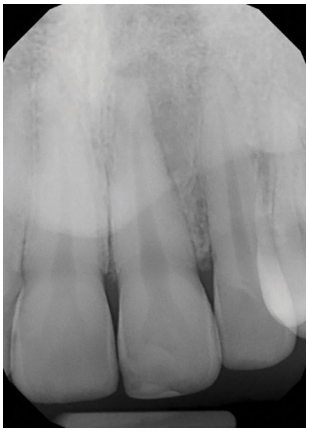

Fig. 1 Previously traumatised, non-vital 21 tooth in a young adult. Wide root canal. Large eccentrically positioned periapical lesion

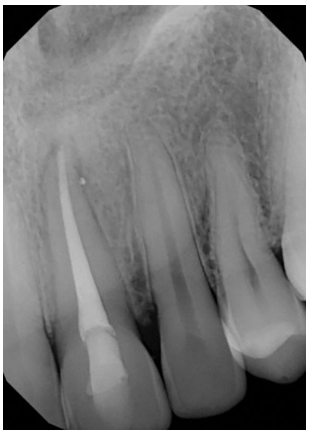

Fig. 2 Twelve-month follow-up radiograph. Unnecessary over-widening of the access cavity was avoided. Access cavity was restored using: GIC (over the gutta percha), flowable composite (over the GIC), and surfaced with a layer of nano-filled universal composite resin. Note filled lateral canal and healing of the periapical lesion

[1]Enhanced Practitioner, Defence Centre for Rehabilitative Dentistry, Evelyn Woods Road, Aldershot, GU11 2LS, UK; [2]Director of Clinical Dentistry, Peninsula Dental School (University of Plymouth), UK; [3]Consultant in Restorative Dentistry, Defence Centre for Rehabilitative Dentistry, Evelyn Woods Road, Aldershot, GU11 2LS, UK.

allowable concentration of hydrogen peroxide in dental bleaching products within the EU/UK has been limited to 6%.[5] In the authors' experience, bleaching agents at this lower concentration are ineffective for use with the walking-bleach technique, but are suitable for use with the combined internal/external bleaching technique. Whilst some relapse in discolouration may occur over time, due to the infiltration of pigments via craze and crack-lines, 85% colour stability for bleached teeth has been reported at 25 years.[6] The risks and benefits of bleaching should be weighed up and discussed with the patient as part of the consent process.

c. The authors' protocol for internal/external bleaching includes the following steps:
   i. Pre-operative photographs of the tooth are taken alongside a representative shade tab to enable an objective assessment of the relative success of treatment
   ii. Impressions for study casts are taken, and a lab-made flexible or Essix-type bleaching tray is requested
   iii. Rubber dam isolation of the affected tooth (and adjacent teeth to facilitate orientation of the bur within the palatal access cavity). Under magnification (loupes or microscope if available), dental materials are then carefully removed from the pulp chamber in two stages: bulk removal, and removal of remnants. Bulk removal of restorative materials is undertaken with a long-tapered course diamond bur in a high-speed handpiece, taking care to avoid removal of tooth tissue. If a well-colour-matched restorative material has been used previously, this can be difficult to visualise. Rubbing the tip of a metal probe over the walls of the access cavity will tend to leave a grey mark on composite/glass-ionomer cement (GIC) remnants, but will not mark dentine/enamel, and helps to avoid unnecessary removal of tooth tissue. Any small tags of restorative material can often be dislodged with a DG16 probe or ultrasonic scaler, whilst root canal sealer residue can be removed from the walls by scrubbing them with a Tepe brush (TePe, Malmö, Sweden) soaked in a suitable solvent (eg eucalyptus oil). The pulp horns are then explored with a DG16 probe. Where necessary, access to the pulp horns can be further developed with a suitably sized Meisinger pulp chamber bur, prior to chemical debridement/disinfection with 1–5% sodium hypochlorite solution
   iv. The gutta percha root filling should then be trimmed back to a level 2 mm apical to the amelo-cemental junction (ACJ) using either a heated plugger, ultrasonic scaler, or Gates Glidden drill. The root filling should then be sealed via careful placement of a 2 mm layer of GIC up to the level of the ACJ.[7] The seal protects the root filling from bacterial ingress, and potentially offers more protection to the ACJ zone to collateral damage from the bleaching agent: a potential risk factor for external cervical resorption. In placing the seal, care should be taken to avoid GIC getting onto the walls of the pulp chamber (above the level of the ACJ), as this will inhibit the permeation of bleach into dentine in that area. The authors find that by using an encapsulated GIC, a line of material can be piped across the back of a gloved hand, and the setting carefully monitored until it starts to enter the rubbery phase, at which point a portion of the material is then carried over to the tooth and packed down with a Machtou plugger
   v. Sometimes, removing the discoloured materials from the pulp chamber negates the need for bleaching and, once the pulp chamber has been cleared of debris, the (dis)colouration of the tooth and requirement for bleaching should be reassessed
   vi. Where progression to internal/external bleaching is indicated, several syringes of either 10% or 16% carbamide peroxide (respectively releasing 3.6% or 5.7% hydrogen peroxide) should be issued to the patient, and a demonstration given as to how to place bleaching gel into both the access cavity and bleaching tray (at the position corresponding to the tooth to be bleached). We advise our patients to wear their bleaching tray for 2–4 hours per day initially, and if no side effects are encountered after the first two days (eg troublesome chemical irritation of the gingivae or dentine sensitivity), then the frequency and duration of wear (up to overnight wear) can be increased by the patient. The patient is instructed on how to keep the access cavity clean at home using a suitably sized TePe brush +/- lavage with tap water via a syringe with 23-gauge blunt-ended needle (Monoject, Kendall, Nashville, USA)
   vii. The patient should attend for review at one, two, and four weeks to assess the progress of the treatment
   viii. If the pulp chamber has been prepared in accordance with this protocol, and the patient is compliant with the bleaching regime, the majority of improvement tends to occur within the first week. However, where required, limited further whitening can

Table 1 Intrinsic and extrinsic causes of discoloured root-treated teeth

Cause	Mechanism	Appearance of crown	Management
Intrinsic	Leakage of haemolytic breakdown products into dentine, subsequently metabolised by bacteria	Uniform grey appearance	Bleaching
	Remnants of pulp tissue in pulp horn(s)	Localised grey/ brown discolouration in coronal-third	Mechanical and chemical debridement of the pulp horns +/- bleaching
	Partial or complete calcification of root canal(s)	Uniform yellow appearance	Bleaching
	Gutta percha or root canal sealer within pulp chamber	Localised band of discolouration, consistent with the coronal extent of material	Removal of materials from pulp chamber +/- bleaching as required
	Mineral Trioxide Aggregate (MTA) (via bismuth oxide component)	Dependent on the coronal extent of the MTA, but often localised to the gingival-third	Opacious veneering material to disguise
Extrinsic	Dietary (eg tea, coffee, red wine, etc) or tobacco-related stain	May be adsorbed onto the surface of the tooth, but may also leach into tooth tissue via craze and crack-lines	Bleaching followed by surface sealing with resin bonded composite to prevent further ingress of stain

often be achieved by extending bleaching duration out to four weeks. Following completion of non-vital bleaching the access cavity should be definitively restored as soon as possible. Where surface craze/crack-lines are present on the labial aspect, sealing of the surface layer with bonded composite resin can reduce the risk of rebound discolouration.

4. Restoration of the access cavity

a. Following completion of RCT (or bleaching), the access cavity should be definitively restored as soon as possible to help support residual tooth structure and create an effective coronal seal. Meticulous technique is required to avoid the creation of air inclusions within the restoration.

b. In the depths of the access cavity, where dentine bonding agent and composite resin cannot be predictably cured, GIC can be packed in place as a base using the methods previously discussed.

c. At cavity depths of <5 mm, predictable light curing can be achieved. Light curing from the incisal aspect should be supplemented with additional light curing from the labial and palatal aspects (where a limited amount of light may penetrate the tooth tissue). Following acid etching and application/cure of a dentine bonding agent, the base may be (further) built up using a flowable composite resin such as Smart Dentine Replacement (SDR) (Dentsply Caulk, Milford, USA). This material has excellent wettability and readily adapts to the cavity walls. To avoid air inclusions, the applicator tip of the flowable composite should be inserted into the cavity base before slowly injecting the material, and simultaneously slowly withdrawing the applicator from the cavity. The material will tend to slump due to gravity, and if required, can be quickly manipulated with a probe prior to curing.

d. The final increment of composite should be a harder wearing universal-type composite such as Filtek Supreme XTE (3M ESPE, Seefeld, Germany). Use of a composite modelling instrument, such as OptraSculpt (Ivoclar Vivadent, Amherst, USA), improves the efficiency and accuracy of composite placement prior to finishing with a composite polishing system (as required).

5. Definitive direct vs indirect restoration

a. Composite resin provides an effective definitive direct restoration in a root-filled anterior tooth where: >50% of coronal tooth tissue remains and there is sufficient pulp chamber to retain the core;[8] there is a ring of enamel for bonding; and tooth discolouration can be camouflaged by composite overlay. However, the clinician must consider that the dentine-resin bond strength may be reduced via:
   i. The presence of restorative material residue on the dentine surface, and within the medial end of the dentinal tubules
   ii. Differences in the nature of the dentine substrate within the pulp chamber compared to that on the outer aspects of the tooth, namely: pre-dentine vs dentine, and wider diameter of dentinal tubules on the inner aspect of the tooth.

b. Where a discoloured root-filled anterior tooth has not responded to bleaching, and the patient is seeking a restoration to camouflage this, a porcelain laminate veneer restoration may be appropriate where: the tooth is largely unrestored (except for the access cavity), the enamel on the labial face of the tooth is intact and bruxing or parafunctional forces can be controlled.

6. Porcelain laminate veneers

a. The provision of a porcelain laminate veneer often requires tooth preparation, which is an irreversible process. To provide a sufficient thickness of opacious material, a veneer on a discoloured tooth will often need to be ≥0.7 mm (although this can be thinner in non-discoloured cases). Alternatively, a shallower tooth preparation can be undertaken, accepting that this will increase the mesial-distal thickness of the crown.

b. The relative advantages of using an indirect restoration to mask out discoloured tooth tissue should be balanced against the disadvantages of reducing tooth structure, potentially increasing the risk of crown fracture, and should be fully discussed with the patient as part of the consent process.

c. When specifying porcelain laminate veneers for discoloured teeth, the authors include the following aspects on the labwork prescription:
   i. Material: eg lithium disilicate with opaquing layer
   ii. Shade map of the tooth tissue
   iii. Desired shade and characterisation of veneer.

> 'If vital bleaching is unsuccessful, then the aesthetics of the tooth can often be improved via minimal tooth preparation and provision of a low-translucency opacious porcelain veneer.'

We hope you have found these hints and tips helpful. Management of broken-down anterior root-filled teeth, including the use of post/cores and crowns, will be discussed in Part 2 of this series. ■

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