Intracoronal bleaching of pulpless discolored lower incisors

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Abstract
Intracoronal bleaching of pulpless discolored lower incisors is a valuable treatment modality currently disregarded by many clinicians because of the potentially disastrous consequence of cervical resorption. A patient-administered, intracoronal carbamide peroxide bleaching technique is described. This modified walking bleaching method minimizes the risks, because treatment time is reduced to days as opposed to weeks of the original walking bleaching protocol, the concentration of the hydrogen peroxide is markedly reduced, and residual hydrogen peroxide is completely eliminated with the use of catalase prior to the definitive restoration

Introduction
It is difficult for practitioners in clinical practice to read and assemble published information into a logical treatment philosophy, consequently a number of restorative concepts have been promulgated through a process of intuitive empiricism. For all intents and purposes operative dentistry is a skills based activity and it is understandable that practical sense-data has been accepted as valid information without appropriate certification. Procedures formerly established without the stringency of the scientific method unfortunately tend to linger in spite of incongruous evidence. The restoration of pulpless anterior teeth is a working example of empirical misconstruction that has pervaded clinical practice.

Rethinking traditional treatment
The post-core restoration is one of the earliest restorations known to man, dating back some 3000 years to the Etruscans.[1] It has been widely held that endodontic teeth required reinforcement with cast posts and cores[2], presently the significance of endodontic treatment in reducing tooth strength has been questioned.[3] The majority of the literature is unanimous with evidence that there is no advantage from the point of view of fracture mechanics in restoring intact root-treated teeth with posts of any form whatsoever.[4,5] Nevertheless the most recent survey of US dentists found that 50% of respondents believed that a post does indeed reinforce an endodontically treated tooth.[6] The restoration of an endodontically treated anterior tooth involves the restitution of esthetics and resistance to fracture. Traditionally these requisites have been accomplished with procedures ranging from veneers of composite or porcelain, to complete coverage with porcelain-fused-to-metal or all-ceramic crowns. Posts and cores, formerly regarded as the optimum foundation[7], are now restricted to the severely decimated clinical crown as recent investigations confirm that the intact natural crown of an endodontically treated tooth provides maximum resistance to root fracture.[8] The biological conservative alternative is to limit restoration to the restitution of lost intracoronal substance.

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Lower discolored pulpless teeth – a unique dilemma
Treating discolored lower intact anterior teeth with indirect restorations presents a unique dilemma; the requisite tooth preparation diminishes and severely weakens the restricted mesial-distal substance of the previously intact tooth. In these instances post/core reinforcement is needed to restitute resistance form to the now compromised coronal portion of the prepared tooth. Post placement can induce internal stresses during

Figure 1a: Preoperative view of a severely discolored central maxillary incisor subsequent to a traumatic episode and endodontic treatment some fifteen years ago.

Figure 1b: 24 hour post-walking bleach result. Note acceptable restitution of natural color.

placement and function[9], notably placement in the restricted bulk and dimensions of lower incisors is not without risk.[10] Ceramic restorations coupled with esthetic posts and cores provide an acceptable treatment option for patients wishing to improve the color of nonvital anterior teeth.[11] Ceramic techniques, however, are costly, invasive, and require ongoing maintenance and prospective replacement. Clearly the described technique is equally effective in the upper dentition (Figure 1a and b). The case report of this paper is of the lower dentition as the single lower incisor is an esthetic challenge in that it is only rarely satisfactorily addressed with indirect restorations given that color matches of restorations to natural dentition are still problematic in clinical dentistry.[12] It is unrealistic to expect that natural color can be consistently achieved with an indirect restoration given the need for an opaque layer to mask highly chromatic intrinsic stains of anterior teeth.[13] In this author's experience residual necrotic tissue is commonly found in the pulp horn remnants of discolored pulpless lower incisors. Presumably the minimal bulk of these incisors encourages minimum access with consequent incomplete extirpation. With degeneration of the pulpal remnants extravasated erythrocytes invade dentinal tubules, release iron on lysis which in turn combines with hydrogen sulfide to form a black iron sulfide compound which causes the tooth to appear darker.[14] Fortunately chemical treatment of discoloration caused by the continued presence of necrotic tissue is exceptionally effective.[15] It would appear from the aforementioned that bleaching discolored intact pulpless anterior teeth would be a feasible treatment option providing the bleaching does not compromise the integrity of the tooth and its supporting complex nor eliminate any future treatment options.

History of bleaching pulpless teeth

Intracoronal bleaching of pulpless discolored teeth is a valuable treatment modality, provided that the procedures are administered with due regard for the relative risks involved. The first account of lightening a nonvital tooth dates back to 1877, when oxalic acid acted as the bleaching agent. [16] Hydrogen peroxide succeeded this technique, as reported by Harlan[17] in 1884. Several techniques that aimed at activating the bleaching agent to expedite the process were then introduced,[18] and in 1961, Spasser introduced his perborate technique.[19] Nutting and Poe improved the perborate technique by combining it with Superoxol and described their "walking" bleaching technique in a 1963 publication.[20] Since then, many articles[21] proposing various combinations of previously reported materials and techniques have appeared in the literature.

There is currently little agreement as to the accepted protocol for nonvital bleaching. There is, however, consensus regarding the potential risks. Risks include cervical resorption, fracture during the multiple treatment period, under lightening and overlightening, and the possibility of color regression. The two basic techniques are the thermocatalytic method and the walking bleaching techniques. The primary difference between the two methods is the way in which nascent oxygen is released from the chemicals. With the thermocatalytic method, various forms of heat are used to speed up the release of oxygen. Both methods have lost favor, however,

Figure 2a: Preoperative view of a severely discolored central mandibular incisor subsequent to a traumatic episode and endodontic treatment.

Figure 2b: A resin-modified glass-ionomer seals the radicular canal from the coronal region. The patient is given a tube of 10% carbamide peroxide and instructed to flush and fill the pulp chamber every 2 hours until the desired tooth lightening is reached.

because of the incidence of external root resorption.[22]

It is reasonable to assume, however, based on the aforementioned clinical and in vitro studies, that it is the presence of bleach in the attachment apparatus that causes local necrosis followed by inflammation and root resorption. It is this author's opinion that the modified method presented in this article minimizes the risks, because treatment time is reduced to days rather than weeks, as required in the original walking bleaching protocol.[20]

Case report

An adult female patient presented with a request for a "crown" to correct the color of a discolored mandibular central incisor (Figure 2a). The tooth had previously been endodontically treated following a traumatic episode. The tooth was asymptomatic. Percussion and radiographic examination revealed a successful endodontic effort with no periapical or periodontal lesions.

Through a process of fully informed consent, the concept of intracoronal bleaching was introduced as the most conservative means of improving the color of the pulpless tooth. The associated risks were identified, and the modified walking bleaching technique was proposed as a cost-effective, rapid, and conservative treatment option. The most favorable result would preserve the natural tooth structure and save the patient the cost and risk of an indirect restoration.

Bleaching Technique

The technique utilizes patient-applied carbamide peroxide and a clear custom-made splint to retain and seal the intracoronal medicament. The author has previously described this intracoronal technique.[23] and subsequent publications have reported favourably on the efficacy of the protocol.[24,25] 10% carbamide peroxide disassociates into 3.35% hydrogen peroxide and urea[26], and, therefore, the intracoronal technique is inherently harmful, given the potential for cervical root resorption. The focus of the protocol to be described is on obtaining an adequate cervical seal that will prevent the hydrogen peroxide from penetrating the root at the cementoenamel junction (CEJ) and on assuring the total elimination of residual hydrogen peroxide. The technique is remarkably simple; the patient fills the pulp chamber with carbamide peroxide and changes the solution on a 2-hourly basis until the desired whitening is achieved. The intracoronal medicament is retained with a clear, custom-made, thermoformed splint.

The appropriate preoperative preparatory steps include informed consent, with emphasis on the associated risks, radiographic evaluation of the endodontic and periodontal status, and a photographic baseline notation.

The tooth is isolated with dental dam in preparation for the meticulous removal of the existing intracoronal restoration (Figure 2b). Utilization of the dental dam is not mandatory, given the low causticity of carbamide peroxide; however, as with all operative options, the access rubber dam brings to the procedure is unrivaled. Single-tooth isolation, while convenient, is not recommended, because full exposure of the adjacent clinical crowns provides the clinician with crucial orientation to root angulation and inclination. This is particularly important if the radiograph reveals the presence of a tooth-colored restorative plug in the coronal portion of the obturated root canal.

The coronal restoration is removed carefully, to limit debridement to existing restorative material and residual necrotic pulp tissue. A triangular access cavity is more favourable from an operative point of view as it is the residual pulpal horns which are apt to cause discoloration. However, recent adhesive guidelines emphasize conservation of tooth substance. Coronal gutta-percha is best removed with a controlled heating instrument, such as the Touch 'N Heat system (Analytic Technology), which allows the nonmechanical excision of gutta-percha. Approximately 3mm of root canal gutta-percha is removed apical to the CEJ. Measurements are made with a rubber stopper; the cavosurface margin of the access opening is used as a reference point. The objective of removing root canal gutta-percha is to create space for the restorative cervical seal and to expose dentinal tubules directed toward the cervical region of the tooth. [27]

A calcium hydroxide plug, approximately 1 mm in thickness, is applied to the freshly exposed gutta-percha. This prophylactic step aims to maintain an alkaline medium, because cervical resorption has been associated with a drop in pH at the cervical level.[28]

The remaining 2-mm depth of the cervical root canal access is "sealed" with one of the resin-modified glass-ionomer materials. Although this seal is not as crucial when carbamide peroxide is used (as opposed to 35% hydrogen peroxide), it is nevertheless crucial to seal the root canal from bacterial ingress during bleaching to prevent contamination of the gutta-percha filling (a major cause of endodontic failure).[29] This author prefers Vitremer (3M Dental), because the viscosity allows precise, bubble-free application through the needle tube applicator of a Centrix syringe (Centrix).

Rotary instrumentation is used to "refresh" the interior of the pulp chamber, to expose coronal dentinal tubules that were inadvertently sealed during priming and application of the restorative plug. Liquid orthophosphoric acid is used to flood the inside of the access cavity for 15 seconds to remove the smear layer. Acid etching will open the dentinal tubules facilitating greater and faster diffusion of the radicals through the dentin. [21]

A soft splint is fabricated on a working cast and trimmed to the dimensions of a custom sports mouthguard (to approximate the attached gingiva buccally and a portion of the lingual mucosa. The patient is given a tube of neutral-pH, 10% carbamide peroxide and instructed to fill the pulp chamber every 2 hours until the desired tooth lightening is reached. A 10-mL Monoject syringe (Sherwood Medical) is used to flush the pulp chamber with warm water prior to replenishment of the carbamide peroxide gel. The patient rehearses the placement of the 10% CP in the office. The splint is used to retain the bleaching agent and to prevent ingress of debris into the access cavity. In addition, the splint serves as a reminder to the patient that full incisal and torquing functions are to be avoided while the tooth is in its hollow, unrestored state.

The patient is cautioned as to the celerity of the response, and the consequent potential for overbleaching is stressed. Mild-to-moderate (two to four shade guides darker than the adjacent teeth) color variances generally require five to eight applications at 2-hour intervals. Patients are encouraged to limit applications to daylight hours, when reliable assessments of color can be made. Continual night-time applications are reserved for severely discolored teeth.

Facial enamel bleaching is seldom required; however, the bleaching tray does facilitate the traditional bleaching protocol, should it be considered necessary. The access cavity is restored with a dentin-colored resin composite once satisfactory color shift has been accomplished.

Importance of final restoration

Bleaching with carbamide peroxide relies on an oxidation-reduction reaction to change the color of teeth. The free radicals perhydroxyl and oxygen diffuse through the dentinal tubules and break down the double bonds in the chromophore structure of organic molecules to produce simpler molecules, which have less absorption energy and effectively reflect less light, thereby producing the whitening effect. This reaction will ultimately reach a saturation point and the bleaching effect ceases. This chemical reaction is believed to be a permanent alteration although some bleached teeth do discolor after varying periods of time. This "relapse" is thought to be the result of microleakage of the restoration in the access cavity and not reduction of previously oxidized chromophores.[30] It is vitally important that the definitive restoration be meticulously delivered with full regard for marginal integrity and longevity of the seal at the restorative tooth interface.

The splint is removed, and the access cavity is flooded with water from a three-in-one syringe in preparation for resin composite shade selection. This is done with out dental dam. An uncured increment of resin composite is inserted into the pulpal chamber, and the effect on the overall color is noted. This resin composite mockup is repeated until the appropriate dentinal shade is selected.

The tooth is isolated with dental dam in preparation for

Figure 2c: Once the desired tooth whitening has been achieved the patient returns for the definitive composite resin restoration. Catalase is applied intracoronally to eliminate the hydrogen peroxide residues.

the definitive restoration. Swift reported that the primary cause of reduced bond strength following bleaching is probably the presence of residual peroxides or oxygen, which interferes with polymerization of resin bonding systems and restorative materials.[31] The definitive restorative procedure therefore must include the removal of residual hydrogen peroxide.

Previous research has shown that water rinses of the pulp chamber immediately after bleaching may not effect rapid neutralization of the residual toxic peroxides.[32] The most recent walking bleaching guidelines[27] have recommended that the pulp chamber be obturated with a calcium hydroxide and water paste, which is left in the chamber for 7 days. This procedure is intended to render neutral the pH in the cervical region of the tooth, offering adequate means of repair to any possible damage to the cervical periodontal ligament. This time period between bleaching and restoration is also advocated to allow the elimination of residual oxygen capable of interfering with the resin polymerization process.[33] The use of a neutral-pH carbamide peroxide solution together with the use of an enzyme to eliminate hydrogen peroxide obviates the need for an interim dressing and facilitates immediate restoration.

Catalase, also known as H_2O_2 oxidoreductase, is an essential enzyme for the proper functioning of the body's defense mechanism. Catalase acts by promoting the reactions involved in the decomposition of hydrogen peroxide to water and oxygen.[34] Catalase changes two molecules of H_2O_2 to two molecules of H_2O and O_2. Because it is an enzymatic reaction, the rate is rapid (it accelerates the decomposition by more than 100 million–fold), and practically independent of temperature, with a broad optimum pH. It has been shown that application of catalase to teeth immediately after bleaching eliminated the hydrogen peroxide residues and prevents their radicular penetration.[34] This author uses a sponge pledget to apply the catalase, leaves the pledget in situ for a period of 3 minutes (Figure 2c), and then flushes the pulp chamber with water for 2 minutes. The pulp chamber (dentin and enamel) and cavosurface margin of the access cavity are acid etched for 15 seconds with 37% phosphoric acid and treated according to the chosen adhesive protocol. It is recommended that an acetone-based adhesive system (such as Prime& Bond NT, Dentsply) be used, because these solvents have previously been shown to reverse the adverse effects of bleaching on enamel bond strengths.[35] Recent literature has shown no such reversal using ethanol based dentin adhesive.[36]

The previously selected (prior to dental dam application) resin composite is incrementally added (Figure 2d) and polymerized from the facial surface.(Figure 2e). The longevity of the color correction achieved by this modified walking bleach technique is reliant upon the quality of the lingual restoration rather than the bleaching procedure itself. A baseline radiograph must be obtained to accredit annual evaluation. If a cervical inflammatory process is diagnosed, calcium hydroxide therapy must be started immediately.[27]

Discussion

It has been suggested that hydrogen peroxide may cause damage to the tooth and surrounding attachment apparatus.[37] In addition, the resorptive potential of residual hydrogen peroxide has highlighted the

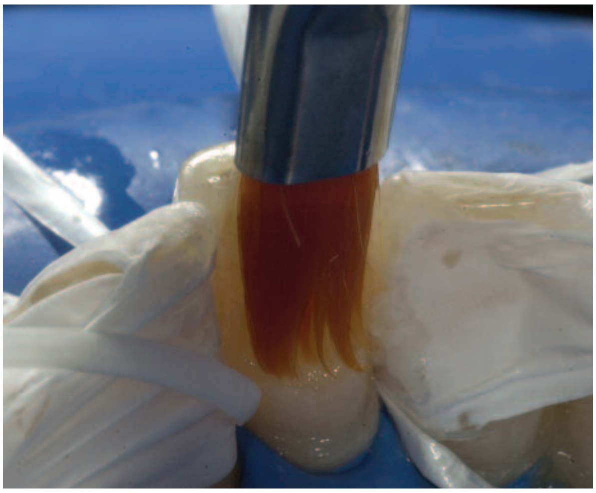

Figure 2d: The composite resin final lingual increment is contoured with a sable artists brush.

Figure 2e: Polymerization of intracoronal composite resin initiated from the facial with glycerine gel applied to lingual surface.

importance of preventing hydrogen peroxide from penetrating the root through to the attachment apparatus. The focus of the protocol of this article has therefore been on obtaining an adequate cervical seal. An understanding of the anatomic complexities of the attachment apparatus is crucial when the objective of the cervical seal is accepted as being to physically block the passage of the bleaching agent from within the tooth to the root surface. Essentially, the passageway from the bleach-filled root canal to the connective tissue cells of the periodontal tissues is the dentinal tubular system. These tubules course apically as a sigmoid curve from the root surface or dentinoenamel junction to the canal wall. Selection of the appropriate anatomic locality of the cervical seal is therefore essential.

Often, bleaching efforts are applied to adolescent patients, in whom passive eruption affects the cementodentoenamel junction and makes assessment difficult. The level of attachment is generally curvilinear, rather than linear, and coincides with the level of the supporting bone. In health, the level of attachment is more coronal at the lingual aspect than at the facial aspect. Potentially a linear seal may adequately block the facial dentinal passageways but still leave the lingual dentinal tubules patent. Although diligence in the selection of the locality of the cervical seal is paramount, irrespective of the age of a patient, the patency[38] and permeability[39] of the tubule lumen decrease with age. Because cementum can act as a deterrent to the diffusion of hydrogen peroxide[40] it is pertinent to note that its permeability[41] decreases and its thickness increases[42] with age. Thus, it is clear that provision of an adequate cervical seal is critical especially in adolescent patients.

The main benefit of the prescribed technique is that a less concentrated solution of unheated peroxide is utilized. This has potential safety consequences for both office staff and patients. Repeated replenishment allows for a rapid technique that is far more convenient and cost effective than the traditional walking bleaching technique. The disadvantage relates to patient compliance, because it is essentially a patient-applied technique that requires that the patient return for a final restoration. Overbleaching can be of concern; however regression, as with all tooth-bleaching procedures[43] can be expected 1 or 2 weeks after a bleaching regimen is completed. Unlike the traditional walking bleaching technique, this method allows the patient to discontinue refilling the pulp chamber once the desired color has been reached. If overbleaching occurs, the bleaching tray can be utilized in the conventional manner to apply carbamide peroxide to the facial surfaces of the adjacent teeth to correct the color mismatch (Figure 2f).

Further research

Because of the small number of teeth treated over the past 12 years, no definitive prognosis can be drawn from the limited, though impressive, results to date. Bizhang and others from Humboldt-University Berlin, Germany recently completed a clinical study comparing the effectiveness of various bleaching techniques.44 Their study included the previously published modified walking bleach technique of this author.23 Sixty discolored, non-vital teeth were divided into three groups and treated with one of the bleaching materials and methods The results showed that the technique described in this paper produced a significantly better post-bleaching, whitening

Figure 2f: Final postoperative result. Note complete disappearance of discoloration and restitution of natural opalescence.

effect than other techniques. At six months the technique was as effective as the sodium perborate mixed with 3% hydrogen peroxide technique.

Summary

A modified walking bleaching technique that relies on patient-administered intracoronal carbamide peroxide has been presented. Notwithstanding the fact that the hydrogen peroxide is administered in a neutral and less concentrated solution, the emphasis of the operative description has been on assuring the complete elimination of residual hydrogen peroxide in an effort to minimize the resorptive complications of previous dentist-applied nonvital bleaching protocols.

Teeth that are recently discolored as a result of pulpal breakdown appear to have an excellent prognosis when the modified walking bleaching technique is used.

The advantage of the described technique is the conservation of the intact tooth structure which avoids the need for a traditional cast post-core and laboratory fabricated restoration. The form and function of the tooth is unaltered with no change in natural occlusion.

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