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AVALIAÇÃO *IN VITRO* DA ADESÃO DE RESTAURAÇÕES DE RESINA COMPOSTA EM DENTES SUBMETIDOS AO CLAREAMENTO DENTAL INTERNO

Dissertação apresentada à Faculdade de Odontologia de Piracicaba, da Universidade Estadual de Campinas, para obtenção do título de Mestre em Clínica Odontológica - Área de concentração – Dentística.

PIRACICABA
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PIRACICABA
2003

Ficha Catalográfica

Sh63a

Shinohara, Mirela Sanae.
Avaliação *in vitro* da adesão de restaurações de resina composta em dentes submetidos ao clareamento dental interno. / Mirela Sanae Shinohara. -- Piracicaba, SP : [s.n.], 2003.
xx, 114p. : il.

Orientador : Prof. Dr. Luíz André Freire Pimenta.
Dissertação (Mestrado) – Universidade Estadual de Campinas, Faculdade de Odontologia de Piracicaba.

1. Dentística. 2. Branqueamento. 3. Adesivos dentários. 4. Resinas compostas. 5. Restaurações (Odontologia). 6. Cisalhamento. I. Pimenta, Luíz André Freire. II. Universidade Estadual de Campinas. Faculdade de Odontologia de Piracicaba. III. Título.

Ficha catalográfica elaborada pela Bibliotecária Marilene Girello CRB/8–6159, da Biblioteca da Faculdade de Odontologia de Piracicaba - UNICAMP.

FACULDADE DE ODONTOLOGIA DE PIRACICABA
UNIVERSIDADE ESTADUAL DE CAMPINAS

A Comissão Julgadora dos trabalhos de Defesa de Tese de MESTRADO, em sessão pública realizada em 17 de Fevereiro de 2003, considerou a candidata MIRELA SANAE SHINOHARA aprovada.

1. Prof. Dr. LUIZ ANDRE FREIRE PIMENTA ______________________

2. Prof. Dr. ANDRÉ LUIZ FRAGA BRISO ______________________

3. Prof. Dr. MARIO FERNANDO DE GOES ______________________

Dedico este trabalho, com todo carinho,
aos meus pais **Seiki** e **Yukiko**, alicerces da minha vida,
cujo apoio constante e incondicional foram essenciais nessa etapa.

AGRADECIMENTOS

Ao **Prof. Dr. Luiz André Freire Pimenta**, agradeço pelas oportunidades ao longo dos anos de convivência acadêmica.

A sua confiança me fez...

...aprender, compreender, desenvolver, buscar, lutar pelos conhecimentos,...

...os quais me encorajaram à inspiração científica.

Obrigada!!

À minha família...

...minha eterna gratidão!!

A certeza do apoio e do conforto foi fundamental nos momentos de dificuldades, assim como nas vitórias alcançadas.

Pai, mãe...

...exemplos de perseverança e luta,...

...mas acima de tudo,...

...exemplos para minha vida.

Irmão,...

***...Gilberto**, único, autêntico e exclusivo!!*

O seu talento, sua arte, sua paciência e seus ensinamentos me enriquecem a todo instante.

Obrigada!!

AGRADECIMENTOS

À Deus, pelas bênçãos e oportunidades concedidas. Sua existência nos permite crer que o impossível pode se tornar possível.

"O que prevemos raramente ocorre; o que
menos esperamos geralmente acontece."
Benjamin Disraeli

Ao Diretor da Faculdade de Odontologia de Piracicaba-UNICAMP, Prof. Dr. Thales Rocha de Mattos Filho.

Ao Coordenador Geral de Pós-Graduação da FOP/UNICAMP, Prof. Dr. Lourenço Correr Sobrinho.

À Coordenadora do Curso de Pós-Graduação em Clínica Odontológica da FOP/UNICAMP, Profa. Dra. Brenda Paula Figueiredo A. Gomes.

Aos professores do Departamento de Odontologia Restauradora, Área de Dentística, pelos ensinamentos concedidos durante a Graduação e a Pós-Graduação.

À Profa. Dra. Giselle Maria Marchi Baron, pelo incentivo e apoio durante o período de estágio em busca da Pós-Graduação. Pela atenção e compreensão nos momentos mais difíceis da Pós-Graduação.

À Profa. Dra. Gláucia Maria Bovi Ambrosano, da disciplina de Bioestatística da FOP/UNICAMP, pela execução das análises estatísticas. Pela atenção dispensada em cada questionamento estatístico.

Aos professores da Banca de Qualificação - Prof. Dr. Marcelo Giannini, Prof. Dr. Caio Cezar Randi Ferraz e Prof. Dr. Mauro Antonio de Arruda Nóbilo – pelas correções e observações importantes neste trabalho.

À Ana Karina, pela amizade verdadeira, pelo apoio, pelos conselhos, pelas trocas de idéias e acima de tudo, pela confiança. Altas conversas solidificaram a nossa amizade, mesmo que a distância perdure.

Ao Fabinho e a Alê, pela ajuda absoluta durante a fase experimental deste trabalho. Como também, pela amizade valiosa conquistada no convívio diário. Um prazer imenso é tê-los como amigos... especiais!

À Lá... Lari... Larissa, um dia estagiária, hoje mestranda e companheira de teto, pelo carinho, pela amizade e pelos momentos de descontração. A sua autenticidade contagiante está na alegria de viver presente em todos os seus gestos.

À Ciça, pelo carinho e pelo exemplo de pessoa, tão meiga e delicada quanto forte e determinada. Uma amiga e tanto.

À Carol, dupla de clínica e de seminário, mais que isso... amiga, pelo apoio, pela compreensão e ajuda durante todo o curso de Mestrado, itens essenciais numa amizade. Pela sua participação e cooperação, fundamental neste trabalho.

À Van "ruiva", não somente pelo suporte estatístico, sobretudo pela amizade cultivada ao longo do nosso Mestrado.

Às minhas amigas de Graduação, pela amizade e apoio. Cris Tempesta, grande amiga... sua amizade me trouxe conforto durante esta minha etapa. Fabíola, seu apoio e confiança foram e são incentivos de luta. Jú Kato e Gleice, mesmo que a distância e o tempo estejam presentes, a amizade permanece.

Aos amigos, André Briso, Inger e Paulinha, pelas dicas e incentivos científicos durante minha Graduação, fundamentais e determinantes para o meu aprimoramento.

"Grande parte da vitalidade de uma amizade reside no respeito pelas diferenças, não apenas em desfrutar das semelhanças."
James Frederick

Aos colegas da Turma de Mestrado e Doutorado do Curso de Pós-Graduação em Clínica Odontológica - Área de Concentração Dentística - FOP/UNICAMP, Alessandra, Alex, Ana Cecília, Ana Karina, André, Celso, César, Cláudia, Denise, Fabiana, Fabio, Flávio, Grace, Maria Carolina, Maristela, Patrícia, Ricardo, Rogério, Vanessa Arias e Vanessa Cavalli.

Ao ex-estagiário, Caio, hoje aluno de Mestrado, pelo carinho e o prazer do convívio diário.

Ao Leo e a Roberta, alunos de Pós-Graduação da Área de Materiais Dentários da FOP/UNICAMP, pelo incentivo e ensinamento que me encorajaram buscar novos ideais.

"A cooperação é a convicção plena de que ninguém pode
chegar à meta se não chegarem todos."
Virginia Burden

À funcionária da Área de Dentística FOP/UNICAMP, Paulinha "Crazy", pela eficiência e assistência imediata em qualquer circunstância.

À FGM Produtos Odontológicos e à KG Sorensen, pelo fornecimento de parte dos materiais utilizados nos experimentos deste trabalho.

À Fundação de Amparo à Pesquisa do Estado de São Paulo-FAPESP, pelo apoio financeiro para execução deste trabalho.

Muitas vezes, um simples gesto, um sorriso educado e um olhar carinhoso pode representar mais que uma palavra de conforto. Tantos são os gestos, os sorrisos e os olhares que passam despercebidos, tantas são as pessoas que passam em nossas vidas que caem no esquecimento, mas que perduram nas nossas conquistas. Agradeço a todos que me ajudaram direta ou indiretamente.

"É melhor tentar e falhar,
que preocupar-se e ver a vida passar;
é melhor tentar, ainda que em vão,
que sentar-se fazendo nada até o final.
Eu preferi na chuva caminhar,
quem em dias tristes em casa me esconder.
Prefiro ser feliz, embora louco,
que em conformidade viver..."

Martin Luther King

SUMÁRIO

RESUMO

O clareamento dental interno vem sendo empregado com sucesso no tratamento de dentes não vitais escurecidos. Após o tratamento clareador, muitas restaurações estéticas necessitam ser trocadas. Estudos têm revelado alterações na adesão da resina composta em dentes submetidos ao clareamento, mostrando a importância da avaliação interface dente-resina. Dessa forma, este estudo teve como objetivos: (1) discutir, por meio de uma revisão de literatura, a aplicação clínica do tratamento clareador interno; (2) analisar, através do grau de microinfiltração, a interface adesiva de restaurações classe V de resina composta em dentes submetidos ao clareamento interno; (3) avaliar a resistência de união de três sistemas adesivos em esmalte e dentina após o clareamento interno; (4) avaliar a resistência adesiva da resina composta aos dentes clareados, após diferentes tempos de espera pós clareamento (1, 7, 14 e 21 dias). Nos três estudos laboratoriais, os dentes bovinos foram submetidos ao clareamento interno, utilizando dois tipos de agentes clareadores: pasta de perborato de sódio mais água e peróxido de carbamida a 37% pela técnica *walking bleach*. Os resultados mostraram que o tratamento clareador interferiu na adesão da resina composta ao dente clareado, dependendo do substrato (esmalte ou dentina) e do teste aplicado (microinfiltração ou cisalhamento). O tipo de sistema adesivo utilizado não interferiu nos valores de adesão em dentes clareados. Após um determinado tempo de espera pós clareamento, a resistência de união é restabelecida. Um período de espera pós clareamento de 14 dias é satisfatório para se realizar os procedimentos restauradores tanto em esmalte quanto em dentina.

ABSTRACT

Nonvital bleaching has been successfully used to treat discolored nonvital teeth. After the bleaching treatment, many esthetic restorations need be replaced. Studies have shown alterations in bonding composite resin to teeth submitted to bleaching treatment, highlighting the importance to evaluate tooth-resin interface. Thus, the objectives in this study were: (1) to discuss, following the literature review, the clinical application of nonvital tooth bleaching; (2) to analyze, according to the degree of leakage, the adhesive interface of class V composite resin restorations to teeth submitted to nonvital bleaching; (3) to evaluate the shear bond strength of three adhesive systems on enamel and dentin after nonvital bleaching; (4) to evaluate the shear bond of composite resin to bleached teeth in different time delays after bleaching (1, 7, 14, and 21 days). For the three lab studies, the bovine teeth were submitted to nonvital bleaching, using two bleaching agents: paste of sodium perborate plus water and 37% carbamide peroxide using the 'walking bleach' technique. The results showed that the bleaching treatment interfered in adhesion of composite resin to bleached teeth, depending on the substrate (enamel or dentin) and the test used (microleakage or shear bond strength). The type of adhesive system used did not interfere in shear bond strength values on bleached teeth. After a certain time delay post bleaching, shear bond is recovered. A 14 day period of time delay after bleaching is satisfactory to perform the restorative procedures for both enamel and dentin.

INTRODUÇÃO

O sorriso é alvo de grande valorização estética. A cor dos dentes é uma das características considerada importante para o sucesso do sorriso (BARATIERI *et al.*, 1993). O escurecimento dental pode provocar problemas estéticos para os pacientes que desejam manter uma aparência agradável. Dentes claros bem contornados e alinhados estabelecem os padrões de beleza vigentes.

As alterações de cor podem ser causadas, basicamente, por dois fatores: extrínsecos e intrínsecos. Os extrínsecos são ocasionados pelo consumo excessivo de tabaco, alimentos e bebidas com corantes - como chá e café. Os intrínsecos congênitos (dentinogênese imperfeita e fluorose) ou os adquiridos, provenientes do uso indevido das tetraciclinas e do flúor durante a fase de formação dental, do envelhecimento fisiológico e pela decomposição de sangue intracoronário, provocados por trauma acidental e falhas no tratamento endodôntico (BARATIERI *et al.*, 1993; DE DEUS, 1992).

O clareamento dental é uma alternativa eficaz para o tratamento do escurecimento dental, pois é considerado conservador, de fácil execução e de custo relativamente baixo (HAYWOOD, 1992; ROTSTEIN *et al.*, 1993; RODRIGUES *et al.*, 2000).

Os mecanismos de ação dos agentes clareadores no processo de clareamento não são completamente compreendidos, porém envolvem uma reação de oxidação, na qual as moléculas de peróxido de hidrogênio se quebram, liberando oxigênio e radicais livres de peridroxil, promovendo a quebra das macromoléculas pigmentadas em moléculas menores, proporcionando o clareamento dos dentes (HAYWOOD, 1992; BARATIERI *et al.*, 1993).

O tratamento clareador pode ser de dois tipos: externo (dentes vitais) e interno (dentes não vitais). O primeiro pode ser feito utilizando o peróxido de carbamida em concentrações de 10% a 20% (HAYWOOD, 1992; CREWS *et al.*, 1992; BARATIERI *et al.*, 1993; LEONARD *et al.*,1998) em moldeiras (caseiro), com peróxido de carbamida a 35% ou peróxido de hidrogênio a 30-35% (consultório)(BARATIERI *et al.*, 1993). O segundo, para dentes desvitalizados, utiliza as técnicas termocatalítica, *walking bleach* e/ou a combinação de ambas (FRECCIA *et al.*, 1982), podendo ser com peróxido de hidrogênio ou com uma mistura de perborato de sódio e água destilada (FRECCIA *et al.*, 1982; WARREN *et al.*, 1990; MACLSAAC & HOEN, 1994; RODRIGUES *et al.*, 2000), o peróxido de carbamida a 37% também pode ser utilizado (SHINOHARA *et al.*, 2001; BARREIROS *et al.*, 2002).

Na técnica termocatalítica, aplica-se peróxido de hidrogênio a 35% associado ao calor, o qual acelera a reação de clareamento (FRECCIA *et al.*, 1982). A aplicação de calor promove a difusão do peróxido de hidrogênio, considerado cáustico (BARATIERI *et al.*, 1993), através dos túbulos dentinários atingindo os ligamentos periodontais. Isto pode provocar um processo inflamatório, causando reabsorção cervical externa (HARRINGTON & NATKIN, 1979; LADO *et al.*;1983; MACLSAAC & HOEN, 1994). Devido a estes problemas, esta técnica e o peróxido de hidrogênio como agente clareador têm sido evitados.

Tão efetiva quanto a termocatalítica, a técnica *walking bleach* que utiliza perborato de sódio e água, tem sido a mais recomendada e aplicada (REEVES *et* *al.*,1995; RODRIGUES *et al.*, 2000), por ser uma técnica fácil, envolver menor tempo clínico e evitar os possíveis riscos do uso do peróxido de hidrogênio.

Como o emprego do clareamento dental interno induz a realização de novas restaurações estéticas nos dentes clareados, é importante avaliar o efeito do agente clareador sobre a estrutura dental e materiais restauradores (TITLEY *et al.*, 1988; TORNECK *et al.*, 1990; TITLEY *et al.*, 1991; CRIM, 1992; TOKO & HISAMITSU, 1993; DISHMAN *et al.*, 1994; BARKHORDAR *et al.*, 1997; CAMPOS, 1998; PERDIGÃO *et al.*, 1998) sendo o tempo de espera pós clareamento de fundamental importância na adesão do sistema adesivo à estrutura dental (FRECCIA *et al.*, 1982; CAMPOS, 1998).

Observou-se, por meio de testes de cisalhamento, que em restaurações em dentes submetidos ao clareamento há diminuição significativa na resistência adesiva da resina composta à estrutura dental clareada (STOKES *et al.*, 1992; TOKO & HISAMITSU, 1993; BARKHORDAR *et al.*, 1997), o que sugere alteração no mecanismo de adesão resina-dente (STOKES *et al.*, 1992; TOKO & HISAMITSU, 1993). DISHMAN *et al.* (1994) constataram que a queda imediata na adesão em dentes submetidos ao clareamento ocorre devido à inibição no processo de polimerização das resinas pela presença de oxigênio. Entretanto, a resistência adesiva foi estabelecida após 1 e 7 dias.

Os resultados obtidos em estudos realizados com dentes bovinos, substitutos eficazes dos dentes humanos na avaliação *in vitro* da adesão de compósitos (NAKAMICHI *et al.*, 1983, REEVES *et al.*, 1995), mostraram-se semelhantes aos resultados em estudos com dentes humanos. Dentes bovinos clareados e restaurados com resinas compostas apresentaram uma queda na resistência adesiva (TITLEY *et al.*, 1988; TORNECK *et al.*, 1990; TITLEY *et al.*, 1991), provavelmente devido à presença de resíduos de peróxido próximos à superfície do esmalte, alterando a adesão da resina (TORNECK *et al.*, 1990; TITLEY *et al.*, 1991).

Testes de microinfiltração também foram realizados em restaurações de compósito em esmalte dental tratados com peróxido de carbamida 10%. Observou-se maior infiltração nestes quando comparados àqueles realizados antes do clareamento. Tal ocorrência sugere a presença de radicais livres e oxigênio alterando a adesão das resinas compostas (BARKHORDAR *et al.*, 1997).

Foi constatado que dentes humanos, submetidos ao clareamento externo com peróxido de carbamida 10%, sofreram interferência na adesão de resinas compostas à estrutura dental, acarretando maior microinfiltração. Após 21 dias verificou-se que a adesão foi recuperada (CAMPOS, 1998). Em contrapartida, CRIM (1992) observou que dentes clareados com peróxido de carbamida 10%, não apresentaram aumento significativo na microinfiltração em restaurações Classe V realizadas logo após o tratamento clareador.

PERDIGÃO *et al.* (1998) avaliaram o efeito do agente clareador a base de peróxido de carbamida 10% na interface esmalte-resina. Verificaram que o clareamento vital não causa mudança significativa na concentração de oxigênio na camada superficial do esmalte, mas produz alterações morfológicas na camada mais superficial dos cristais do esmalte. Sabe-se, através de vários relatos na literatura, que os agentes clareadores provocam alteração na adesão dos compósitos (STOKES *et al.*, 1992; TOKO & HISAMITSU, 1993; DISHMAN *et al.*, 1994; BARKHORDAR *et al.*, 1997; CAMPOS, 1998), mas o agente causador da diminuição na resistência adesiva pós clareamento não está definido.

Tais alterações na adesão da resina composta a dentes clareados implicam na necessidade da avaliação da interface dente-resina, por meio do grau de microinfiltração, bem como a resistência adesiva de restaurações de resinas compostas utilizando diferentes sistemas adesivos e diferentes tempos de espera pós clareamento. Tais avaliações objetivaram a segurança na realização de restaurações sem a interferência dos subprodutos dos agentes clareadores, pois se houver falhas no selamento das margens, o sucesso da restauração estará comprometido.

PROPOSIÇÃO

Este estudo, composto por 4 capítulos, teve como objetivos:

(1) discutir, por meio de uma revisão de literatura, a aplicação clínica do clareamento interno.

(2) analisar, através do grau de microinfiltração, a interface adesiva de restaurações classe V de resina composta realizadas em dentes submetidos ao clareamento interno.

(3) avaliar a resistência de união de três sistemas adesivos em esmalte e dentina após o clareamento interno.

(4) avaliar a resistência adesiva da resina composta aos dentes clareados, após diferentes tempos de espera pós clareamento (1, 7, 14 e 21 dias).

3.1. CAPÍTULO 1

Clareamento interno: revisão de literatura

(aceito para publicação na Revista Gaúcha de Odontologia – RGO)

CAPÍTULO 1

CLAREAMENTO INTERNO: REVISÃO DE LITERATURA

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SINOPSE: A terapia endodôntica ocasionalmente apresenta o efeito indesejável de escurecimento dental pós-tratamento. A busca dos pacientes pela reversão de quadros de desarmonia estética por dentes com manchas ou alteração de cor, para dentes devidamente clareados ou recuperados esteticamente por outros meios, aumenta a cada dia. O profissional deve estar ciente não só do diagnóstico destes quadros desarmônicos, mas também da melhor opção de tratamento para cada caso.

INTRODUÇÃO

Após a remoção da polpa dental, o dente pode perder a sua translucidez, principalmente por causa da desidratação dos tecidos dentais. A perda discreta da translucidez pode ser revertida pela obturação adequada da câmara pulpar (2). O endodontista deve estar ciente que a aplicação da técnica endodôntica e a escolha da medicação são de grande importância para prevenir a alteração de cor da coroa dental após o tratamento e a obturação do canal (2).

Frente a um dente tratado endodonticamente que apresenta qualquer tipo de descoloração dental, o profissional pode lançar mão de alguns tipos de tratamento: manter o dente intacto, clarear o dente; recuperar a estética do dente através de manobras restauradoras ou protéticas, ou ainda associar as técnicas clareadoras com as restauradoras (2, 13).

O clareamento é a tentativa mais conservadora de restabelecer a cor normal dos dentes, através da descoloração das manchas dentais por processos de oxidação ou redução (3). Sendo assim, o clareamento de dentes não vitais é um passo da terapia odontológica simples e de resultados previsíveis, na busca de um perfil estético capaz de alterar significantemente a auto-estima de nossos pacientes.

Do ponto de vista estético e prático, os dentes anteriores e, em casos de um sorriso mais amplo, os pré-molares, são os dentes que exigem condutas clareadoras.

Para se executar as técnicas de clareamento com total segurança, o canal radicular deve estar hermeticamente obturado; a coroa dental deve estar relativamente intacta; deve-se remover toda e qualquer dentina escurecida e/ou amolecida; substituir restaurações, quando estas são responsáveis pelo escurecimento da coroa (2). A presença de fraturas, fendas, hipoplasias e outras alterações da estrutura do esmalte podem também dificultar ou até contra-indicar o clareamento interno (2).

De acordo com GOLDSTEIN (4), as manchas e alterações dos dentes despolpados de interesse endodôntico imediato podem ser causadas pelos seguintes fatores: materiais restauradores; hemorragia intracoronária; decomposição de detritos intrapulpares; medicamentos de uso intracanal e materiais obturadores. Estes resíduos podem penetrar através dos túbulos dentinários, resultando em um quadro de descoloração dental.

MECANISMO DE AÇÃO DOS AGENTES CLAREADORES

O clareamento de dentes desvitalizados já era realizado desde o final do século XIX, através da utilização de várias substâncias, tais como: óxido oxálico (1), hipoclorito de cálcio (22), peróxido de hidrogênio (5) e pirozona (22), sendo que o primeiro relato de clareamento de dentes não vitais data de 1877, a partir da utilização de ácido oxálico por Chapple (1).

Os agentes clareadores usados normalmente atuam por reações de oxidação (3). Estes agentes apresentam baixo peso molecular e capacidade de desnaturar proteínas, possibilitando o "trânsito" de íons através da estrutura dental (6). O peróxido de hidrogênio se decompõe em radicais livres, oxigênio e água (7). Por serem fortes agentes oxidantes estas substâncias reagem com as macromoléculas responsáveis pelos pigmentos, e por um processo de oxidação, os materiais orgânicos são convertidos em compostos com menor pesos moleculares, e eventualmente em dióxido de carbono e água, removendo os pigmentos da estrutura dentária por difusão (7), resultando em um efeito clareador.

Um agente clareador que tem sido amplamente utilizado é o Superoxol®, uma solução de peróxido de hidrogênio a 30% em água destilada (15). O Superoxol® é considerado um potente agente oxidante, por apresentar uma grande concentração de oxigênio liberada, facilitando assim sua penetração por entre os espaços interprismáticos e pelos canalículos dentinários (4).

Já o mecanismo de ação do peróxido de carbamida a 37% está baseado na dissociação em aproximadamente 25% de uréia e 10% de peróxido de hidrogênio (7). O principal benefício da utilização deste material está na baixa concentração de peróxido de hidrogênio liberada, bem como na presença de uréia. A uréia é um composto que regula o pH intracoronário durante o processo clareador (7). O baixo pH intracoronário, associado à difusão de peróxido de hidrogênio por entre os túbulos dentinários em direção às fibras do ligamento periodontal, pode dar início a uma reação inflamatória podendo resultar em um quadro de reabsorção radicular externa (6, 17, 8).

A aplicação de géis claredores (com peróxido de hidrogênio ou carbamida em concentração média de 35%) ativados através de fontes de luz ou calor como os lasers de argônio ou LED´s (Light Emitting Diodes) também tiveram seu uso muito difundido nos últimos anos (23). As emissões fotônicas emitidas por estes aparelhos são radiações não-ionizantes, que resultam em efeitos fotoquímicos e fototérmicos, tendo como alvo somente moléculas escurecidas (16). Esses mecanismos geram um aumento mínimo de temperatura sem dano ao tecido pulpar, pois aquecem o produto, e não a estrutura dental. O ideal é obter um pico de emissão de energia do ativador (laser, LED´s) muito próximo ao espectro de absorção do agente clareador (16, 23), alcançando deste modo, um efeito preciso e específico para o clareamento dental.

O perborato de sódio é um pó estável, e quando em solução com água, se decompõe em metaborato de sódio, oxigênio e peróxido de hidrogênio em uma concentração mais baixa, entre 10% e 16% (21, 6) - sendo que a taxa de liberação de oxigênio ativo está diretamente ligada ao grau de hidratação do perborato de sódio. Em seguida, o peróxido de hidrogênio libera oxigênio ativo, dando início ao processo clareador (6, 7). SPASSER (21), em 1961, propôs a utilização da pasta de perborato de sódio e água para ser colocada no interior da câmara pulpar, dispensando o uso de calor produzido por lâmpadas e instrumentos metálicos levados ao rubro.

Uma alternativa para o perborato de sódio é o percarbonato de sódio (11). No Japão, o percarbonato é normalmente utilizado como detergente, já que a eficácia deste agente quando comparada com o perborato de sódio - para as baixas temperaturas japonesas – é muito maior. O percarbonato de sódio se dissocia em carbonato de sódio e peróxido de hidrogênio, com uma porcentagem de oxigênio livre em torno de 9,9%.

CLASSIFICAÇÃO DAS TÉCNICAS

As técnicas mais amplamente utilizadas no clareamento de dentes despolpados são as técnicas denominadas termocatalítica e *walking bleach*. A maior diferença entre as duas técnicas é o método de liberação do oxigênio ativo dos compostos químicos clareadores (3).

Na técnica termocatalítica, o calor é usado para liberar oxigênio ativo do agente clareador, normalmente peróxido de hidrogênio a uma concentração de 30% (3). O calor catalisa os produtos de decomposição dos agentes clareadores em radicais livres oxidantes instáveis, bem como "impulsiona" os agentes clareadores através de processos de expansão e difusão por entre os túbulos dentinários.

Já a técnica *walking bleach*, proposta inicialmente por SPASSER (21), utiliza como agente clareador o perborato de sódio. Uma pasta espessa de perborato de sódio e água destilada é inserida na cavidade pulpar, o dente é posteriormente selado e o agente clareador mantido na cavidade por no mínimo três dias, podendo ser renovado por até mais três sessões. Esta técnica foi denominada como *walking bleach*, já que o processo de clareamento ocorre entre as consultas, durante o período em que o agente clareador permanece selado na câmara pulpar.

Uma modificação da técnica *walking bleach* foi publicada por NUTTING & POE (15) em 1967, baseada na substituição da água destilada pelo peróxido de hidrogênio a 30%. Esta seria uma tentativa de se potencializar o efeito clareador, já que tanto o perborato de sódio quanto o peróxido de hidrogênio apresentam capacidade de liberar oxigênio.

A técnica *walking bleach* apresenta a vantagem de requerer menor tempo clínico, quando comparada às técnicas termocatalítica ou a combinação de ambas (3). No entanto, vale ressaltar que normalmente o tempo de tratamento com a técnica termocatalítica é mais curto. A utilização da combinação do perborato de sódio tetrahidratado com água destilada, como agente clareador em dentes despolpados, é a mais recomendada por sua segurança, em virtude da redução do risco potencial do desenvolvimento de um quadro de reabsorção radicular externa na região cervical (3). A baixa concentração de peróxido de hidrogênio liberada pelo perborato de sódio em conjunto com a água destilada é um dos principais fatores que asseguram a segurança desta técnica (9, 17).

Existem relatos da associação das duas técnicas supracitadas, sendo a termocatalítica realizada no consultório, seguida pela *walking bleach* entre as sessões, na tentativa de se obter um resultado estético rápido e eficaz (3). No entanto, o prognóstico deste tipo de sinergismo, principalmente quanto à segurança, é extremamente duvidoso, principalmente quanto ao risco de reabsorções radiculares externas.

FRECCIA *et al.* (3) compararam três técnicas de clareamento para dentes despolpados: termocatalítica, *walking bleach* (combinação de perborato de sódio e Superoxol) e a combinação de ambas. Todas demonstraram ser efetivas, mas a técnica *walking bleach* apresentou como vantagem um menor tempo clínico, além de oferecer menores riscos de reações adversas nos tecidos periradiculares.

HO & GOERIG (9) avaliaram a efetividade da técnica *walking bleach* quando da utilização de uma pasta de perborato de sódio e água ou de uma pasta de perborato de sódio e Superoxol. Observaram um efeito clareador e mais rápido com a combinação de perborato de sódio e Superoxol. No entanto, ressaltam que além da maior segurança da técnica que usa água como solução, o efeito clareador conseguido é o mesmo, somente levando um maior período de tempo.

Uma outra modificação da técnica *walking bleach* com o uso de peróxido de carbamida 10% foi recentemente proposta (13, 19). Esta técnica foi denominada *inside/outside*, consistindo na aplicação do agente clareador tanto na parte externa quanto na parte interna do dente de uma maneira simultânea, ou seja, a câmara pulpar não é vedada (13, 19). De acordo com os autores, a grande vantagem deste tratamento é o curto período de tempo necessário para a obtenção do efeito clareador necessário. Contudo, a manutenção da câmara pulpar aberta pode comprometer o selamento biológico, promovido inicialmente pelo tratamento endodôntico e pelo tampão cervical, além do fato de dificultar a higienização da cavidade pelo paciente.

KANEKO *et al.* (11) em 2000, avaliaram a eficiência clareadora do percarbonato de sódio em dentes artificialmente pigmentados através da utilização de um colorímetro. Os resultados mostraram que o percarbonato de sódio, quando associado com água destilada ou peróxido de hidrogênio, apresenta resultados similares ao perborato de sódio com água, mostrando ser um efetivo agente clareador. No entanto, não há na literatura muitos relatos avaliando os efeitos do percarbonato no clareamento de dentes não vitais, bem como a influência deste agente sobre as estruturas dentais e os materiais de base, para que haja uma segura aplicabilidade clínica deste material.

O clareamento de dentes não vitais também pode ser realizado no consultório, através da aplicação de géis clareadores (com peróxido de hidrogênio ou carbamida em concentração média de 35%) somente no dente escurecido (23). Estes géis possuem diferentes tonalidades, de acordo com o espectro de luz mais bem absorvido, sendo que o peróxido de hidrogênio é ativado através de diferentes fontes de luz ou calor, com diferentes potências e comprimentos de onda, tais como: Laser de Argônio, Laser de Diodo, LED´s e Lâmpadas de Xenônio / Arco de Plasma (23). O efeito do clareamento com o uso destes equipamentos é também conseguido através de processos químicos de oxidação, já que os iniciadores fotossensíveis do produto clareador absorvem a energia fototérmica e ativam a quebra do peróxido de hidrogênio (16, 23).

PROCEDIMENTOS RESTAURADORES

Após o término dos procedimentos clareadores, uma bolinha de algodão deve ser temporariamente inserida no interior da câmara pulpar, por um período mínimo de uma semana, para permitir a completa eliminação do agente clareador e seus produtos de decomposição - principalmente oxigênio residual – da câmara pulpar, para que não haja interferência no processo de polimerização dos materiais resinosos (23).

Alguns autores recomendam que após o término da aplicação do agente clareador, a câmara pulpar seja totalmente preenchida com uma pasta de hidróxido de cálcio e água, sendo mantida na câmara pulpar por 7 dias (12). Este procedimento visa reverter o pH da região cervical para uma normalidade, reduzindo assim os riscos de um futuro quadro de reabsorção radicular externa, principalmente após a utilização de Superoxol, como agente clareador.

SHINOHARA *et al.* (20), em um trabalho avaliando a influência do perborato de sódio e do peróxido de carbamida na adesão de cavidades classe V em resina composta, observaram um aumento da microinfiltração marginal nas margens dentinárias, mas não observaram o mesmo efeito em margens de esmalte. Segundo os autores, as cavidades foram confeccionadas 24 horas após o término do tratamento, os resíduos dos agentes clareadores - como peróxidos, água e oxigênio - podem ter comprometido a ultramorfologia da interface dente-restauração, aumentando a solubilidade das estruturas dentais, principalmente da dentina.

Tendo em vista que a restauração definitiva em dentes anteriores é comumente realizada com compósitos, o profissional deve ter cuidado quando da utilização de materiais forradores e provisórios à base de eugenol, já que estes cimentos podem comprometer o processo de polimerização das resinas (14). Logo, o uso destes materiais previamente ao clareamento deve ser considerado de acordo com o plano de tratamento restaurador e a conveniência clínica do operador (18).

Os híbridos de ionômero de vidro apresentam propriedades físicas e mecânicas ideais para esta finalidade (14). Estes materiais são fotopolimerizáveis, conferindo uma fácil manipulação por parte do operador. Além disso, estes materiais possuem adesividade à estrutura dental, são biocompatíveis, apresentam coeficiente de expansão térmica similar ao dente e tem total compatibilidade com as resinas compostas (14).

Após condicionamento ácido total da cavidade por 15 segundos e aplicação de um sistema adesivo hidrófilo, deve-se preencher a câmara pulpar incrementalmente com resina composta de acordo com as recomendações do fabricante. Em seguida, o profissional deve checar os contatos oclusais e realizar os procedimentos de acabamento e polimento de praxe para restaurações em resina composta.

Uma das mais indesejáveis complicações decorrentes do clareamento de dentes não vitais, quando da utilização de peróxido de hidrogênio como agente oxidante, é o desenvolvimento de reabsorções radiculares externas (6). No entanto, o mecanismo exato deste processo de reabsorção induzida pelo agente clareador ainda não é completamente explicado. O que provavelmente ocorre é uma percolagem de peróxido de hidrogênio proveniente da câmara pulpar através dos túbulos dentinários em direção aos tecidos periodontais, principalmente na presença de defeitos cementários (17). Assim, o peróxido de hidrogênio daria início a uma reação inflamatória no ligamento periodontal, em função de uma queda de pH, levando a um quadro final de reabsorção radicular externa (17, 18).

Uma proteção na base da câmara pulpar, recobrindo a obturação radicular, deve ser empregada anteriormente à inserção do agente clareador, buscando a obliteração dos túbulos dentinários da região, e conseqüentemente, prevenindo a passagem do peróxido de hidrogênio em direção aos tecidos extrarradiculares, além de proteger a obturação radicular de guta-percha de contaminantes bacterianos.

ROTSTEIN *et al.* (18) avaliando a eficiência de diferentes materiais de base pré clareamento, não observaram diferenças na penetração de peróxido de hidrogênio entre a utilização de IRM, pasta de óxido de zinco, resina composta e ionômero de vidro. No entanto, postulou-se que a espessura desta camada protetora em relação à altura da junção cemento-esmalte é mais crítica na prevenção da penetração do peróxido de hidrogênio do que o tipo de material protetor utilizado. A espessura recomendada é de aproximadamente 2mm, ao nível da junção cemento-esmalte, sem que haja comprometimento do resultado estético, tanto do ponto de vista clareador quanto restaurador.

Os cimentos de ionômero de vidro modificados por resina possuem boa adesão à estrutura dental, são resistentes à ação dos agentes clareadores sem comprometer o clareamento, são estéticos, de fácil manipulação e inserção, apresentam boa adesividade à estrutura dental, além de não comprometerem a restauração final (14).

O processo de reabsorção radicular externa está relacionado ao uso da técnica *walking bleach* quando da associação do peróxido de hidrogênio com perborato de sódio (6). HELLER *et al.* (8), em um estudo com cães, relataram casos de reabsorção radicular externa em 2 dos 16 dentes tratados pela técnica *walking bleach* (com associação de peróxido de hidrogênio e perborato de sódio) em um período de 3 meses pós tratamento.

Avaliações *in vitro* de alterações em dentes clareados mostram a ocorrência de uma queda de pH a valores ácidos quando da utilização de peróxido de hidrogênio em combinação com perborato de sódio (12), bem como um aumento das taxas perirradiculares de peróxido de hidrogênio (17).

Outras complicações relacionadas aos procedimentos de clareamento interno são: risco de fratura durante os múltiplos períodos de tratamento, subclareamento, "overlighting", bem como a regressão da cor do dente clareado (10).

PROGNÓSTICO (CLAREAMENTO / RESTAURADOR)

O paciente deverá ser reavaliado um mês após o término do tratamento. Um fator importante a ser considerado é o grande efeito clareador conseguido logo após o término do tratamento clareador, normalmente sucedido por uma leve recidiva da cor dental. O efeito clareador do produto combinado com a desidratação dental, decorrente do isolamento absoluto, pode explicar a melhora da descoloração dental ao final de cada sessão. A subseqüente rehidratação do tecido dental, em conjunto com uma possível neo-redução das moléculas de pigmentos, inicialmente oxidadas pelo agente clareador, bem como umas novas impregnações de pigmentos extrínsecas (3) podem explicar tal recidiva.

O prognóstico do sucesso de qualquer técnica de clareamento dental está diretamente relacionado à etiologia da descoloração dental (10). Quando a alteração de cor é causada por produtos de decomposição pulpar, o prognóstico é extremamente favorável. Contudo, em manchas metálicas causadas por medicamentos que contém prata ou por restaurações de amalgama, o prognóstico é mais duvidoso, sendo mais difícil de alcançar resultados satisfatórios (10). Além disso, a probabilidade de uma recidiva é muito maior nestes casos. HOWELL (10) mostrou que quanto mais trabalhoso o clareamento de um dente, maior a probabilidade de uma recidiva.

CONCLUSÕES

O clareamento interno é uma técnica confortável e indolor para o paciente, permitindo um clareamento seletivo, com possibilidade de múltiplas aplicações, permitindo um controle da coloração dental desejada, tanto por parte do profissional quanto do paciente.

A melhora imediata da descoloração dental já nas primeiras sessões dá ao paciente uma maior auto-estima, além de confiabilidade no tratamento e no profissional. No entanto, o paciente deve sempre estar ciente de eventuais recidivas nos dentes tratados, principalmente nos primeiros 7 dias de tratamento, a qual progressivamente diminui a cada sessão.

É necessário que se tenha um bom acompanhamento clínico e radiográfico do dente clareado, a fim de que se verifique a segurança do método e dos produtos utilizados, bem como a estabilidade dos resultados decorrentes do tratamento clareador e restaurador.

RESUMO

Atualmente, um dos aspectos mais estimados no conjunto estético da face é o sorriso. Este fato estimulou o desenvolvimento de técnicas e materiais que proporcionem um resultado mais harmonioso, que satisfaça os anseios do paciente. Antigamente, dentes que apresentavam anomalias de cor recebiam desgastes, para em seguida, serem reconstruídos através de procedimentos diretos ou indiretos. Hoje, o profissional pode contar com técnicas altamente eficazes e seguras que possibilitam a reversão destes quadros de alteração de cor. O clareamento é a tentativa mais conservadora de restabelecer a cor normal dos dentes, através da descoloração das manchas dentais por processos de oxidação ou redução. Sendo assim, o objetivo deste trabalho elucidar, através de uma revisão de literatura, as principais técnicas e procedimentos necessários para o clareamento de dentes não vitais.

SUMMARY

Nowadays, one of the most estimated aspects of facial beauty is the smile. This concern pushed the development of new materials and techniques that have the potential to reverse these esthetics disturbs, helping patients to have better confidence and self-esteem. Lately, discolored anterior teeth were grounded in order to receive direct or indirect rehabilitation. Dental practitioners are now dealing with extremely effective and safe cosmetic techniques. Intracoronal bleaching is one of the most conservative approaches to reestablish endodontically treated, discolored teeth, by means of oxidation and reduction reactions. Therefore, the purpose of this article is to

discuss, by means of a literature review, the procedures and techniques needed for nonvital tooth bleaching.

REFERÊNCIAS BIBLIOGRÁFICAS

1.CHAPPLE, J.A. Restoring discolored teeth to normal. Dent Cosmos., v. 19, p.499, 1877.

2.DE DEUS, Q.D. Clareamento de dentes com alteração de cor. *In:* ________. Endodontia. Rio de Janeiro: Medici, 1992. 383p.

3.FRECCIA, W.F., PETERS, D.D., LORTON, L. *et al.* An *in vitro* comparison of non vital bleaching techniques in the discoloured tooth. J Endodon., v. 8, n. 2, p. 70-77, Feb, 1982.

4.GOLDSTEIN, R.E. Estética em Odontologia (Esthetics in Dentistry). Tradução para o português por DE DEUS, Q.D. Rio de Janeiro: Guanabara Koogan, 1980. 479p.

5.HARLAN, A.W. The removal of stain from teeth caused by administration of medicinal agents and the bleaching of pulpless teeth. Am J Dent Sci., v. 18, p. 521, 1884.

6.HARRINGTON, G.W., NATKIN, E. External root resorption associated with bleaching pulples teeth. J Endodon., v. 5, n. 11, p. 344-348, Nov, 1979.

7.HAYWOOD, V.B., HEYMANN, H.O. Nightguard vital bleaching. Quintessence Int., v. 20, n. 3, p. 173-176, Mar, 1989.

8.HELLER, D., SKRIBER, J., LIN, L.M. Effect of intracoronal bleaching on external cervical root resorption. J Endodon., v. 18, n. 4, p. 145-148, Apr , 1992.

9.HO, S., GOERIG, A.C. An *in vitro* comparison of different bleaching agents in the discolored tooth. J Endod., v. 15, n. 3, p. 106-11, Mar, 1989.

10.HOWELL, R.A. The prognosis of bleached root-filled teeth. Int Dent J., v. 14, n. 1, p. 22-26, Jan, 1981.

11.KANEKO, J., INOUE, S., KAWAKAMI, S. *et al.* Bleaching effect of sodium percarbonate on discolored pulpless teeth in vitro. J Endodon., v. 26, n. 1, p. 25-28, Jan, 2000.

12.KEHOE, J.C. pH reversal following *in vitro* bleaching of pulpless teeth. J Endodon., v. 13, n. 1, p. 6-9, Jan, 1987.

13.LIEBENBERG, W.H. Intracoronal lightening of discoloured pulpless teeth: a modified walking bleach technique. Quintessence Int., v. 28, n. 12, p. 771-777, Dec, 1997. Revisão.

14.MacISAAC A.M., HOEN, M.M. Intracoronal bleaching: concerns and considerations. J Can Dent Assoc., v. 60, n. 1, p. 57-64, Jan, 1994. Revisão.

15.NUTTING, E.B., POE, G.S. Chemical bleaching of discolored endodontically treated teeth. Dent Clin North Am., p. 655-662, Nov, 1967.

16.PHILLIPS, M.S. SKINNER Materiais Dentários. Rio de Janeiro: Travessa do Ouvidor, 1993. 328p.

17.ROTSTEIN, I., TOREK, Y., MISGAV, R. Effect of cementum defects on radicular penetration of 30% H_2O_2 during intracoronal bleaching. J Endodon., v. 17, n. 5, p. 230-233, May, 1991.

18.ROTSTEIN, I., ZYSKIND, D., LEWINSTEIN, I., *et al.* Effect of different protective base materials on hydrogen peroxide leakage during intracoronal bleaching in vitro. J Endodon., 18: 114-7, 1992.

19.SETTEMBRINI, L., GULTZ, J., KAIM, J., *et al.* A technique for bleaching non vital teeth: Inside/outside bleaching. J Am Dent Assoc., v. 128, n. 9, p. 1283-1284, Set, 1997.

20.SHINOHARA, M.S., RODRIGUES, J.A., PIMENTA, L.A.F. In vitro microleakage of composite restorations after nonvital bleaching. Quintessence Int., v. 32, n. 5, p. 413-417, May, 2001.

21.SPASSER, H.F. A simple bleaching technique using sodium perborate. NY State Dent J., v. 27, p. 332-334, 1961.

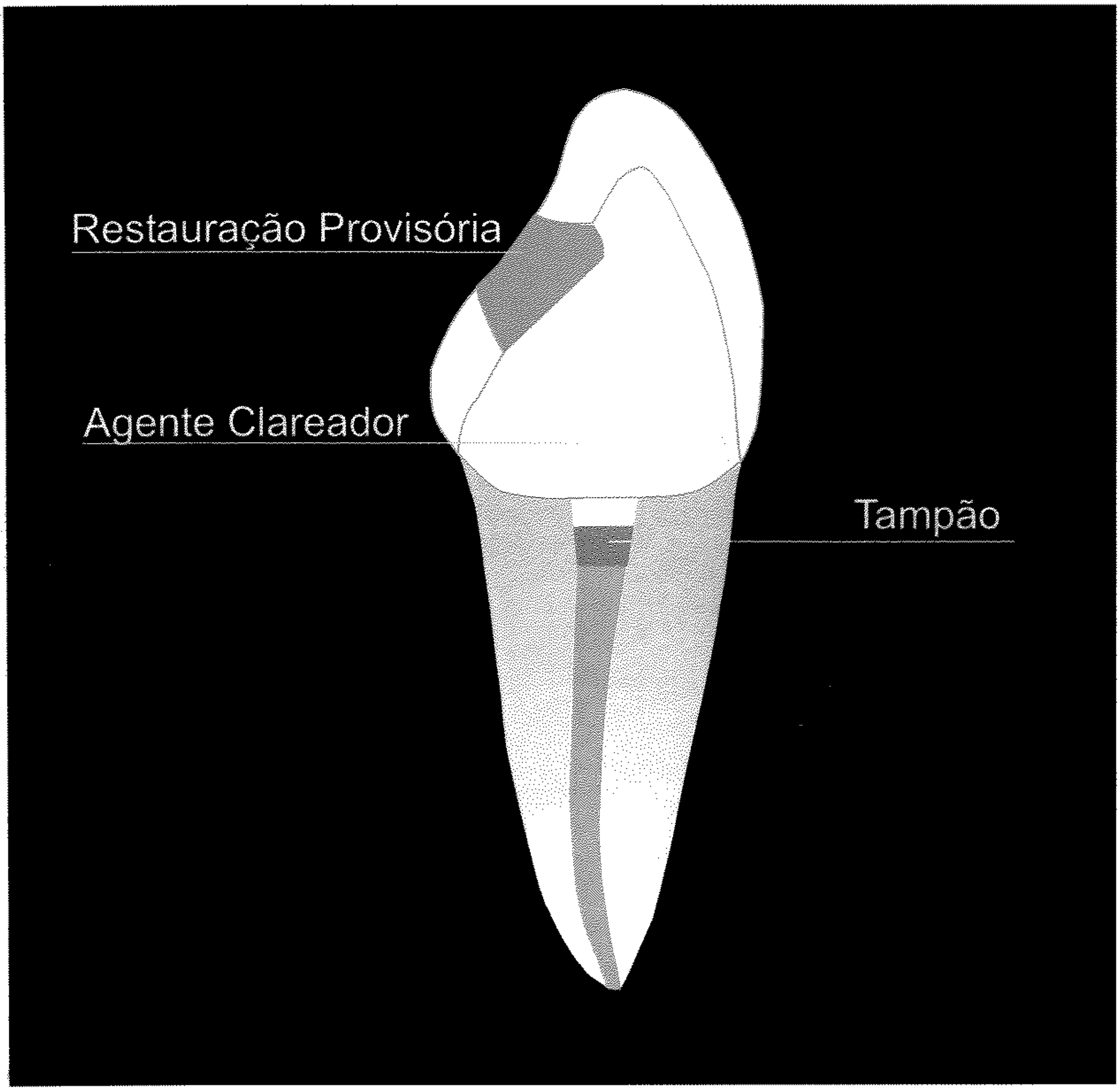
22.TAFT, J. Bleaching teeth. Am J Sci., v. 12, p. 364, 1878.

23.TITLEY, K.C., TORNECK, C.D., RUSE, N.D., *et al.* Adhesion of a resin composite to bleached and unbleached human enamel. J Endodon., v. 19, n. 3, p. 112-115, Mar, 1993.

24.ZANIN, F.; BRUGNERA JUNIOR, A. Técnica de claremanto para dentes desvitalizados com laseres e LED´s. *In:* Clareamento dental com luz-laser. Porto Alegre: RGO, 2002. 30p.

Figura 1. Aspecto esquemático do correto posicionamento do tampão cervical.

Observar sua colocação a aproximadamente 2mm abaixo da junção cemento-esmalte.



3.2. CAPÍTULO 2

In vitro microleakage of composite restorations after nonvital bleaching

(publicado na revista Quintessence International 2001; 32:413-417)

(publicado na revista the Quintessence 2001, 20:195-199, Japan)

CAPÍTULO 2

IN VITRO MICROLEAKAGE OF COMPOSITE RESTORATIONS AFTER NONVITAL BLEACHING

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ABSTRACT

Objective: After bleaching treatment, esthetic restorations often need to be replaced due to color changes. Some papers have shown alterations in the bond of adhesive restorations to bleached teeth. The purpose of this study was to evaluate tooth and resin composite adhesion when submitted to nonvital dental bleaching. **Method and materials:** One hundred and twenty bovine teeth were assigned to 3 groups (n=40): paste of sodium perborate and water; 37% carbamide peroxide gel; and non bleaching (control). After 3 weeks of continuous bleaching treatment, standardized Class V cavities were prepared at the cementoenamel junction and restored with Single Bond adhesive system and Z100 resin composite. The samples were thermocycled 1,500 times (5 ±1/55±1 ^{0}C) with 1-minute dwell time. Then, they were immersed in a 2% methylene blue solution (pH 7) for 4 hours, sectioned, and analyzed by stereomicroscopy. Microleakage analyses were done, using scores from 0 to 4, considering leakage on the incisal wall (enamel) and the cervical wall (dentin). Data were analyzed by Kruskal-Wallis and Mann-Whitney tests (α=0.05). The results showed that sodium perborate and carbamide peroxide gel significantly increase the microleakage in Class V resin composite restorations to dentin but not to enamel margins. **Conclusion:** The risk of microleakage in dentin margins is increased soon after bleaching treatment.

Key words: bleaching agents, discolored tooth, microleakage, nonvital tooth, tooth bleaching, walking bleach

CLINICAL RELEVANCE

After nonvital bleaching with either sodium perborate and water or 37% carbamide peroxide, the seal of new resin composite restorations is jeopardized, resulting in increased microleakage of dentin margins.

INTRODUCTION

Discolored anterior teeth, whether multiple or individual, present a serious esthetic problem. Dental bleaching should be the first step taken in a treatment, since it is the most conservative one.

A preparation of sodium perborate and water in the "walking bleach" technique, for nonvital tooth bleaching, has been the most popular and recommended one, since the decomposition reaction of sodium perborate is slow and releases hydrogen peroxide in low concentration, giving a wider margin of safety in relation to other techniques.[1-4] Another bleaching agent that may be used in the "walking bleach" technique is 37% carbamide peroxide, which has been considered to be safe for the practice.

Once the bleaching process is complete, esthetic restorations may need to be replaced in order to achieve optimal shade matching. Thus, they are always filled with esthetic restorative materials such as resin composite or glass-ionomer cement. The prerequisites of these materials are to prevent microleakage and to improve the esthetic results.[5-7]

Some authors have reported detrimental effects on resin-tooth bonds as well as an increase of microleakage for the teeth restored after bleaching treatment.[6,8,9] This effect is attributed to the presence of residual peroxide or oxygen released from bleaching agents and structural changes on enamel and dentin composition that can affect the seal at the resin-tooth interface.[5,7,9] It is therefore important to know the real effect of the bleaching agents on the dental structure in order to avoid unsuccessful resin restorations.[10]

The purpose of this paper was to evaluate the microleakage of Class V adhesive resin restorations in teeth submitted to nonvital bleaching with two different bleaching agents.

METHOD AND MATERIALS

One hundred and twenty freshly extracted bovine teeth were stored in 2% formalin solution, cleaned, selected, and then stored in distilled water at room temperature to prevent dehydration. The teeth were horizontally sectioned approximately 7mm incisally and apically to the cementoenamel junction using a double-faced diamond disc (reference n°. 7020, KG Sorensen) to produce tooth segments (Fig 1). The contents of the pulp chamber and root canal were removed with a dental explorer, and the pulp chamber was enlarged with a nº. 8 carbide bur using a low-speed handpiece (Kavo).

Three millimeters below the cementoenamel junction, a 3-mm thick base of intermediary restorative material (IRM) (Dentsply) was placed to prevent apical leakage of the bleaching material during the "walking bleach" technique. The teeth stored in a humidor (humidifier) were then randomly assigned to following groups:

- Group 1/sodium perborate (SP): 40 bovine teeth bleached by a paste of sodium perborate (Proderma) and water (2 g of sodium perborate per 1ml of water).
- Group 2/carbamide peroxide (CP): 40 bovine teeth bleached by 37% carbamide peroxide gel (Whiteness, FGM Produtos Odontológicos).
- Group 3/no bleaching (control): 40 nonbleached bovine teeth soaked in distilled water before restoration.

In groups SP and CP, the respective bleaching material was inserted in the pulp chamber, and a 2-mm thick surface seal was made with IRM. The bleaching agents were changed every 7 days for 2 weeks. The bleaching treatments were performed for 21 days. The teeth were stored in a humidor at 37ºC during the bleaching period.

After bleaching, the incisal and the apical regions were sealed with epoxic resin (Araldite Ciba Especialidades Química). A standardized cylindrical Class V cavity preparation (approximately 2.0mm in diameter and 2.0mm in depth) was done in the cementoenamel junction on the facial surface. A special diamond bur (reference n°. 2294/KG Sorensen) in a high-speed handpiece (Kavo) with a constant water-spray coolant was used to prepare the cavities.

Before restoration, all cavities were rinsed with water in order to loosen all sediment left during preparation. Then, they were gently air-dried with air for 2 seconds to avoid dentin dehydration. The adhesive system Single Bond (3M Dental) was placed according to the manufacturer's recommendations. The cavity was etched for 15 seconds with a 35% phosphoric acid gel, and the etchant was rinsed for 10 seconds with water from an air-water syringe and briefly dried with compressed air for 2 seconds. Two consecutive coats of adhesive were applied using a saturated brush tip. After gently air drying for 5 seconds, the material was light cured for 10 seconds. The resin composite Z100 (3M Dental) was inserted in a bulk increment. The restored teeth were stored in a humidor at 37 ± 1°C for 24 hours, and the composite surface was polished with a graded series of Sof-Lex discs (3M Dental).

The teeth were placed in separate mesh bags and thermocycled (MCT2, Instrumental Instrumentos de Precisão) for 1,500 cycles in water between 5 ± 1°C and 55 ± 1°C with a dwell time of 60 seconds in each bath. After thermocycling, the external surface of each tooth was coated with 2 layers of nail varnish, leaving a 1-mm wide margin around the restoration that was free of varnish. The teeth were placed in a 2 % methylene blue solution (pH 7) for 4 hours at room temperature and rinsed under tap water. The teeth were sectioned longitudinally through the center of each restoration with a slow-speed double-faced diamond disc. The right half of each sectioned tooth was evaluated blindly and independently by 3 examiners with a stereomicroscope (Meiji 2000Techno, Meiji Techno) at X35 magnification to determine the extent of microleakage at incisal and gingival margins. The following criteria were used to score dye penetration:

0 = No dye penetration

1 = Dye penetration to 1/3 of the incisal or gingival wall

2 = Dye penetration to 2/3 of the incisal or gingival wall

3 = Dye penetration to full length of the incisal or gingival wall

4 = Dye penetration including axial floor

Data were analyzed by Kruskal-Wallis and Mann-Whitney tests (α=0.05). The test were chosen due to the nature of the qualitative random variable, which employs scores to evaluate the phenomenon under study (microleakage). The statistic calculations were performed by STATA software (Computing Resource Center Stata Reference Manual).

RESULTS

The microleakage median scores, the sum of ranks per bleaching treatment, and pair-wise comparisons for the restorative systems are presented in Table 1. The Kruskal-Wallis test showed no statistically significant differences in microleakage among treatment groups (P=0.063 χ^2 = 5.507; α< 0.05) in enamel margins; however statistically significant differences in microleakage were seen among the treatment groups (p=0.0001 χ^2 = 25.009; α< 0.05) in dentin margins.

Comparisons of the sum of ranks on enamel margins showed no statistically significant differences among control and experimental groups. On dentin margins, comparisons of the sum of ranks in the bleached groups were statistically significant different from the unbleached control group (p<0.05). An increase in microleakage was found in both bleaching groups (SP and CP), showing the adverse potential of sodium perborate and 37% carbamide peroxide.

DISCUSSION

Bleaching procedures are often considered to be the first step in improving the appearance of discolored teeth.[5,11] Nonvital bleaching is often followed by placement of esthetic restorations. One of the prerequisites of such treatment is that the esthetic restoration prevents microleakage.[6] Several studies have shown that hydrogen peroxide released from bleaching agents adversely affects the bond strength of adhesive systems and resin composites to enamel.[6,8,9,12-14]

This work evaluated the influence nonvital bleaching agents might have on the microleakage of Class V adhesive restorations. The control group showed less microleakage in enamel and dentin margins than the bleaching groups (SP and CP). An increase in resin/dentin microleakage was found in groups SP and CP, showing the adverse potential of sodium perborate and 37% carbamide peroxide.

Some evaluations have demonstrated that teeth subjected to 10% carbamide peroxide have greater microleakage compared to nonbleached teeth.[5,8,9,12-16] A previous study proved that bleaching with 10% carbamide peroxide increased microleakage and interfered in the adhesion of resin restorations to dental structures.[17] Another investigation showed no measurable leakage along the enamel margins of Class V resin restorations, but the gingival dentin margins exhibited leakage, although the difference was not statistically significant.[7]

Barkhordar et al stated that bleaching had a minimum effect on the marginal seal of the resin restoration within the first 2 days and a significant effect after 4 to 7 days of bleaching, and concluded that the microleakage increased with the extent of bleaching time.[6]

Shear bond strength measurements and electron microscopy scanning examinations have shown changes in the bonds of resin composites after bleaching.[18-20] Tensile and shear tests of bleached teeth revealed a significant reduction in bond strength that was caused by an alteration in the adhesion mechanism and changes in resin quality at the enamel-resin interface.[6,10,13]

The loss of adhesive strength may be due to bleaching reactions.[8,12,14,20,21] Although these reactions are not totally known, the hypothesis is that as the oxidizing agent hydrogen peroxide diffuses through the dentin and enamel, the highly pigmented carbon ring compounds are opened and then converted into chains, which are lighter in color. As this process continues, the bleached tissue continually lightens with further decomposition of organic and inorganic matrix. During this process, water and oxygen are released.[21,22]

Some authors have suggested that the adverse effects of bleaching on resin-tooth bonds are caused by residual peroxides and oxygen that could inhibit the polymerization process of the adhesive systems.[14,20] In an electron microscopic scanning evaluation, nonbleached teeth presented numerous and clearly defined resin tags, in contrast with the teeth treated with 35% hydrogen peroxide for 30 minutes, where the resin tags were sparse, shorter, poorly defined, and structurally incomplete.[12]

However, a recent research study did not detected oxygen on the surface of bleached enamel, thus rejecting the hypothesis that residual oxygen leached from bleaching agents may interfere in the adhesive polymerization process.[23] Moreover, bleaching can induce changes in the ultra-morphology of enamel-resin bonded interfaces, changing the organic and inorganic component ratios, increasing the solubility of dental structures, and affecting dentin more than enamel.[6,23]

In this study, the microleakage of dentin margins in groups SP and CP was significantly higher than in the control group. However, such a difference did not occur among the enamel margins in groups SP, CP, and control ($P=0.063$). The reason could be the difference in the composition of enamel and dentin. Dentin contains less mineral and more organic matrix and can easily be affected by hydrogen peroxide-based materials. These materials are strong oxidizing agents that may cause denaturation of proteins in the organic components, producing morphologic changes that could reduce the performance of resin bond restorations.

Another consideration is the presence of dentin tubules that may enhance the rate of penetration of the bleaching agents and residual oxygen diffusion from the pulp chamber through dentin. The consequence may be a higher concentration of residual oxygen in the more porous dentin margins than on enamel margins, thereby increasing microleakage.

It should be noted that the teeth used in this investigation were bovine, not human teeth, and the manner in which the bleaching agents were used was not the same as when bleaching is clinically performed.[9] Moreover, in the oral environment, the interaction with saliva may repair the tooth by mineral precipitation, and the action of enzymes (such as peroxidase and catalase) may leach out all residual peroxides and oxygen from the tooth, over an extended period of time, and improve the quality of resin-tooth bonds.[14,17]

It is necessary to know the time that has elapsed from the bleaching treatment to the restoration procedure to achieve an optimal seal, as well as to reduce the risk of microleakage in adhesive restorations.

CONCLUSION

1. Under the experimental circumstances used in this study, the Class V restorations in teeth submitted to nonvital bleaching with 37% carbamide peroxide gel or sodium perborate showed a significant increase in microleakage on dentin margins.
2. On enamel margins, the microleakage was not statistically different from the control group for both bleaching agents.

3. Even with regard to distance, the bleaching agents sodium perborate and 37% carbamide peroxide gel can interfere in the resin-tooth interface.

It is necessary to know the time that has elapsed from the bleaching treatment to the restoration procedure to achieve an optimal seal as well as to reduce the risk of microleakage in adhesive restorations.

ACKNOWLEDGMENTS

The authors would like to acknowledge the support received from Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), grant # 99/00810-3.

REFERENCES

1.Rotstein I, Mor C, Friedman S. Prognosis of intracoronal bleaching with sodium perborate preparations in vitro: 1-year study. J Endod 1993;19:10-12.

2.Freccia WF, Peters DD, Lorton L, Benier WE. An in vitro comparison of nonvital bleaching techniques in the discolored tooth. J Endod 1982;8:70-77.

3.Maclsaac AM, Hoen MM. Intracoronal bleaching: concerns and considerations. Scientific. J Can Dent Assoc 1994;60:57-64.

4.Hara AT, Pimenta LAF. Nonvital tooth bleaching: a 2-year case report. Quintessence Int 1999;30:748-754.

5.Toko T, Hisamitsu H. Shear bond strength of composite resin to unbleached and bleached human dentine. Asia J Aesthet Dent 1993;1:33-36.

6.Barkhordar RA, Kempler D, Plesh O. Effect of nonvital tooth bleaching on microleakage of resin composite restorations. Quintessence Int 1997;28:341-344.

7.Crim GA. Prerestorative bleaching: effect on microleakage of Class V cavities. Quintessence Int 1992;23:823-825.

8.Titley KC, Torneck CD, Smith DC, Adibfar A. Adhesion of composite resin to bleached and unbleached bovine enamel. J Dent Res 1988;67:1523-1528.

9.Torneck CD, Titley KC, Smith DC, Adibfar, A. The influence of time of hydrogen peroxide exposure on the adhesion of composite resin to bleached bovine enamel. J Endod 1990;16:123-128.

10.Garcia-Godoy F, Dodge WW, Donohue M, O'Quinn JA. Composite resin bond strength after enamel bleaching. Operative Dentistry 1993;18:144-147.

11.Baratiere LN, Ritter AV, Monteiro Jr Sim, Andrada MAC, Vieira LCC. Nonvital tooth bleaching: guidelines fo the clinician. Quintessence Int 1995;26:597-608.

12.Titley KC, Torneck CD, Smith DC, Chernecky R, Adibfar A. Scanning electron microscopy observations on the penetration and structure of resin tags in bleached and unbleached bovine enamel. J Endod 1991;17:72-75.

13.Stokes NA, Hood JAA, Dhariwal D, Patel K. Effect of peroxide bleaches on resin-enamel bonds. Quintessence Int 1992;23:769-771.

14.Torneck CD, Titley KC, Smith DC, Adibfar, A. Effect of water leaching on the adhesion of composite resin to bleached and unbleached bovine. enamel. J Endod 1991;17:l56-160.

15.Demarco FF; Turbino ML, Jorge AG, Matson E. Influence of bleaching on dentin bond strength. Am J Dent 1998;11:78-82.

16.Titley KC, Torneck CD, Ruse ND, Krmec D. Adhesion of a resin composite to bleached and unbleached human enamel. J Endod 1993;19:112-115.

17.Pimenta IC. Avaliação qualitativa da microinfiltração em restaurações de resina composta substituídas após o clareamento com gel de peróxido de carbamida.. Tese de mestrado da FOP- Unicamp - Curso de Clínica Odontológica, Piracicaba, 1998.

18.Seghi RR, Denry I. Effects of external bleaching on indentation and abrasion characteristics of human enamel in vitro. J Den Res 1992;71:1340-1344.

19.Attin T, Kielbassa AM, Schwanenberg M, Hellwig E. Effect of fluoride treatment on remineralization of bleached enamel. J Oral Rehabilitation 1997;24:282-286.

20.Tames D, Grando LJ, Tames DR. Alterations on dental enamel submitted to 10% carbamide peroxide. Revista da APCD 1998;52:145-149.

21.Baratiere LN, Monteiro Júnior S, Andrada MAC, Vieira LCC. Clareamento Dental. São Paulo: Quintessence, 1993.

22.Goldstein GR, Kiremidjian-Schumacher L. Bleaching: is it safe and effective? J Prosthet Dent 1993;69:325-328.

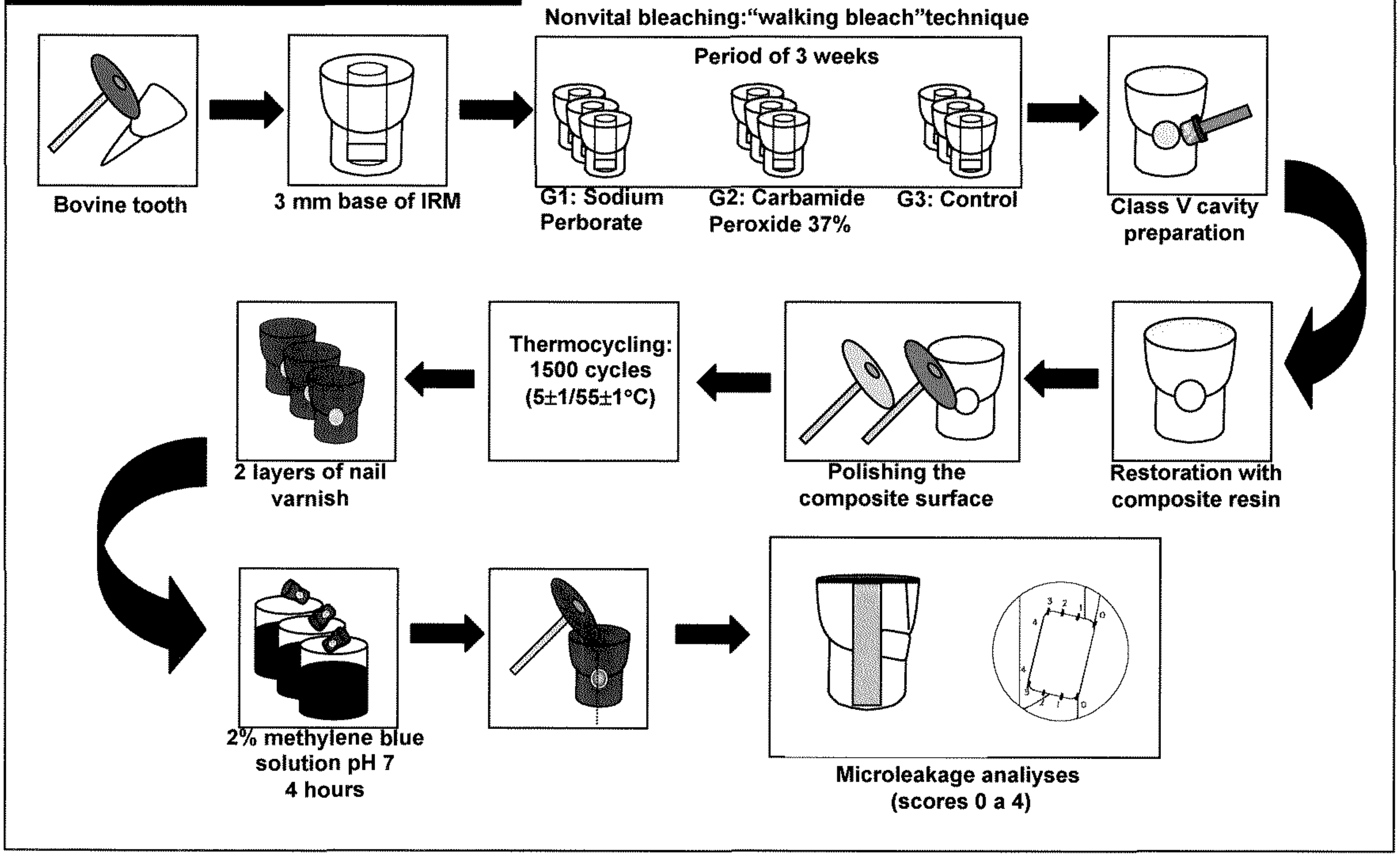
23.Perdigão J, Francci C, Swift E.J. Ultra-morphological study of the interaction of dental adhesives with carbamide peroxide-bleached enamel. Am J Dent 1998;11:291-301.

Table 1. Statistical results.

Table 1 Statistical results						
	Enamel		P=0.063	Dentin		P<0.05
Groups	Median	n	Sum of ranks	Median	n	Sum of ranks
Sodium Perborate	0	37	2104.5 a	1	37	2313.5 a
37%Carbamide Peroxide	0	35	2200.0 a	1	35	2416.0 a
Control	0	37	1690.5 a	0	37	1265.5 b

The difference in letters next to the sum of ranks column expresses the significant statistical differences.

Figure 1 Scheme of the experiment



3.3 CAPÍTULO 3

The effect of nonvital bleaching on the shear bond strength of composite resin using three adhesive systems

(enviado para revista American Journal of Dentistry)

CAPÍTULO 3

THE EFFECT OF NONVITAL BLEACHING ON THE SHEAR BOND STRENGTH OF COMPOSITE RESIN USING THREE ADHESIVE SYSTEMS

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ABSTRACT

Purpose: to evaluate the effect of nonvital bleaching on the shear bond strength of composite resin using three adhesive systems. ***Materials and Methods*:** two-hundred and seventy bovine teeth were assigned into 3 groups (n=90): SP-sodium perborate; CP-37% carbamide peroxide; CO-control group (no treatment). After the bleaching treatment, the teeth in each group were separated to enamel (E) and to dentin (D). The teeth were cut, included in polyester resin, and polished in order to obtain a flat E or D surface. Each group was divided into 6 subgroups (n=15) according to substrate (E and D) and adhesive system: SB-Single Bond; PB-Prime & Bond NT; CLF-Clearfil SE Bond. The adhesive system was applied on each flat surface according to the manufacturer's instructions and a cylinder of composite resin Z-250 was overlaid. The specimens were stored in distilled water for 7 days at 37°C. The SBS test was performed in a Universal Test Machine with crosshead speed of 0.5 mm/min. ***Results:*** the data obtained in MPa were subjected to statistical analyses (Two-way ANOVA and Tukey, $p \leq 0.05$). There was no interaction between bleaching treatment and the adhesive system used. On enamel, the SP and CP bleaching treatments reduced the SBS values. On dentin, the SP bleaching agent reduced the SBS values and the CP bleaching did not interfere on SBS values.

CLINICAL SIGNIFICANCE

Nonvital bleaching treatment with sodium perborate may adversely affect on shear bond strength values of composite resin for both enamel and dentin. 37% Carbamide peroxide bleaching agent interferes on enamel bonding strength, but not on dentin. The use of water/alcohol and acetone-based adhesive systems may not reverse the effects of bleaching treatments on bond strengths.

INTRODUCTION

Discoloration of anterior teeth is a serious esthetic problem in restorative dentistry and it requires effective treatment. Bleaching is the most conservative and economical alternative to better the appearance of the discolored nonvital tooth.[1,2]

The walking bleach is the most popular and recommended technique for endodontically treated teeth.[3,4] This technique involves sealing a bleaching agent in the pulp chamber and changing the solution every week for 3-4 weeks.[4] According to the literature the use of hydrogen peroxide for bleaching has occasionally been associated with the development of external root resorption.[5]

The use of sodium perborate mixed with water is the most accepted bleaching agent to reduce the risk of cervical root resorption.[6] Sodium perborate has a slow process and releases hydrogen peroxide in low concentration.[4,7] Another bleaching agent that can be used is the 37% carbamide peroxide that is considered an efficient and secure bleaching agent to the walking bleach technique.[3,8]

This way, the bleaching agent diffuses from the pulp chamber dentin into the enamel. The bleaching effect is a consequence of an oxidation reaction in the discolored dentin.[9] After the bleaching treatment, previous restorations may need replacement to match the correct shade.[10]

Several studies have shown the adverse effects of bleaching treatment on bond strength between composite resin and tooth substrate.[2,11-23] Some authors have suggested that a reduction on bonding strength of composite resin in bleached teeth may be due to the presence of active chemicals from bleaching agents.[11,14,18,24] Residual oxygen may be responsible for the inhibition of resin polymerization and increase in resin porosity.[11]

Several researchers have found that the optimal bond strengths can be achieved with a time delay after the bleaching.[12-14] According to some findings the use of alcohol-based bonding agents may result in less affected composite bond strength when restorative work is to be completed immediately after bleaching.[15,25] The presence of alcohol may have counteracted any residual water and oxygen from the bleaching agent.[26]

The purpose of this study was to evaluate the effect of three different adhesive systems on shear bond strength of composite resin after nonvital bleaching treatment.

MATERIALS AND METHODS

SPECIMEN PREPARATION TO BLEACHING TREATMENT

Two-hundred and seventy freshly extracted bovine teeth were selected, cleaned, and stored in 0.1% thymol solution prior to the study. Each tooth was horizontally sectioned approximately 11mm occlusally and 7mm apically to the cemento-enamel junction using a double-faced diamond disk[a]. The pulps were removed with a dental probe, and the pulp chamber was enlarged to a standard size using a spherical diamond bur 1016HL[b] using a low-speed handpiece[c].

BLEACHING TREATMENT

A 3-mm thick base material (IRM[d]) was placed in the root canal and leveled 2 mm below the cemento-enamel junction to prevent apical leakage of the bleaching material during the *walking bleach* technique. The apical region was sealed with epoxy resin[e]. The teeth were stored in a humidor at 37°C prior to bleaching treatment.

The specimens were randomly assigned into 3 groups (n=90), according to the bleaching treatment: SP-sodium perborate; CP-37% carbamide peroxide; CO-control. The control group was not bleached. The teeth were stored in artificial saliva at 37°C before the restoration.

The *walking bleach* technique was used for both bleaching agents sodium perborate[f] (2g/1ml) and 37% carbamide peroxide gel[g]. The bleaching materials were inserted in the pulp chamber, and a 1.5mm thick surface seal was made with a temporary material IRM. The bleaching agents were changed every 7 days, for three weeks. The teeth were stored in artificial saliva at 37°C during the bleaching period.

SPECIMEN PREPARATION TO SHEAR BOND STRENGTH TEST

After the bleaching treatment, the specimens were sectioned and the fragments obtained were included in polyester resin[h]. The embedded specimens were polished on a water coolant mechanical grinder[i] using Al_2O_3 sandpapers[j] to expose flat surface areas of 5-6mm^2. Half of the specimens of each group was ground to obtain a flat dentin surface and the other half was ground to obtain a flat enamel surface. After this, a 3mm diameter area was left uncovered as a bonding site by placing a fenestrated PVC film with a 3mm diameter hole over the flat surface (dentin and enamel).

RESTORATIVE PROCEDURES

Following, to obtain the flat surfaces, the specimens of each group (CP, SP and, CO) were divided into 6 subgroups (n=15), according to the adhesive system used (Single Bond-SB; Clearfil SE Bond[l]-CLF; Prime & Bond NT) and flat surface (dentin and enamel).

A piece of tape with a hole (diameter of 3.0mm) was attached to the specimen surface in all groups to limit the area of the bonded surface. Each adhesive system was applied according to the manufacturer's instructions. (Table 1)

After the application of the bonding agent, a bipartite Teflon ring mold with a circular hole of 3.0mm in diameter and 5.0mm in depth was positioned over the treated flat surface (enamel and dentin). The mold was filled with composite resin Z-250[k] and light cured[m] for 40 seconds, then light cured again for an additional 40 second period in opposite directions after removing the mold.

The specimens were immersed in distilled water and stored for one week at 37°C before testing.

BOND STRENGTH TEST

The shear bond strength was measured in a Universal Test Machine[n]. A parallel knife-edge shearing device was aligned over the bonded interface and the force was loaded to failure, using crosshead speed of 0.5mm/min. Means and standard deviations were calculated with units expressed in MPa. The data were subjected to two-way ANOVA and Tukey test (α=0.05).

RESULTS

Mean bond strengths and standard deviations on enamel and dentin are shown in Table 2 and Table 3.

Two-way ANOVA test showed no significant interaction between bond strength to bleaching treatment and the adhesive system used for both enamel and dentin. Statistical significant differences among the groups were indicated ($p \leq 0.05$). The differences were evaluated using the Tukey test.

For enamel, the bleaching treatments with SP and CP reduced the bonding strength values. For dentin, the bleaching treatment with SP reduced the bonding strength values, the CP did not interfere in SBS values.

The results indicated that the bleaching treatment on enamel and dentin interfered in bond strengths, independent from the adhesive system used. Single Bond and Clearfil SE Bond showed significant higher mean bond strength values than the ones of Prime & Bond NT for bleached and unbleached tooth.

DISCUSSION

After nonvital bleaching treatment, the restorative procedure is important to achieve a pleasant appearance, since the color of composite resin must be compatible with the bleached tooth. Moreover, the adhesion of composite resin restoration to the tooth should be able to prevent microleakage and withstand the forces exerted during mastication.[27]

Previous investigations have demonstrated that the bleaching agent interferes with the adhesion of composite resin restoration to dental structures and also contribute to the susceptibility of the tooth surface to microlekage[3,16,28,29]. Our results have confirmed other studies[2,12,13,17-21]. The bleaching treatment interferes in the shear bond strength of composite resin restorations independent from the adhesive system used.

In this study, three adhesive systems were evaluated after immediately nonvital bleaching treatment. According to the some researches, the bonding agent could improve the adhesion on bleached tooth.[15,24,26] Kalili *et al.* suggested that the application of an alcohol-based adhesive system may have been able to minimize the inhibitory effects of the bleaching treatment by the interaction of alcohol with residual oxygen[25] and counteract any residual water and oxygen from the bleaching agent[26]. An interaction of high-pressure solvents (acetone and ethanol) with the higher concentration of water inside the enamel microstructure after bleaching is supposed to occur.[24]

According to the results obtained, Single Bond and Clearfil SE Bond showed significant higher mean bond strength values than the ones of Prime & Bond NT for bleached and unbleached teeth, however there was no interaction between bond strength to bleached tooth and the adhesive system used.

These findings have suggested that the presence of residual peroxides and oxygen may be responsible for the decrease in bond strength.[17,19] The bleaching agent was applied in the pulp chamber, showing that it is able to interfere in the substrate even at distance. The bleaching agent spreads from dentin to enamel.

The bleaching agent alters the enamel and dentin substrate and it may interfere in bond strength of composite resin.[16,18,22,24] The hypothesis of Toko & Hisamitsu is that the adverse effect of hydrogen peroxide could be attributed to the removal of the nonfibrous organic content within the tooth substance.[2] Hydrogen peroxide has been suspected to cause denaturation of proteins in the organic components of dentin and enamel, altering the organic/inorganic ratio with an increase in organic component.[28]

Rotstein *et al.* indicated that most bleaching agents cause changes in the levels of calcium, phosphorus, sulfur, and potassium in the tissues. Calcium and phosphorus are present in the hydroxyapatite crystal, the main building block of dental hard tissues. Changes in Ca/P ratio indicate alterations in the organic components of hydroxyapatite.[31] It seems that bleaching agents may adversely affect dental hard tissues. Perinka *et al.* have found that the dentinal characteristics (dentin thickness, hardness, and Ca-concentration) might influence bond strength of dentin.[32]

Our data demonstrated that both bleaching agents (sodium perborate and 37% carbamide peroxide) interfered in shear bond strength values for enamel when compared to the control group (no treatment). Titley *et al.*, in an electron microscopic scanning evaluation, showed that the resin tags in 35% hydrogen peroxide treated enamel were sparse, shorter, poorly defined, and structurally incomplete.[11]

Some authors have suggested that the decrease in bond strength may be due to the residues of bleaching agents that could inhibit resin polymerization[17,23] and the released oxygen could interfere with the resin infiltration into etched enamel. [17,19,30] Conversely, Perdigão *et al.* stated that the residual oxygen may not be responsible for this effect. The changes in proteins and in mineral content of the most superficial layers of enamel may be responsible for reduced bond strengths.[24]

For dentin, the use of SP decreased in shear bond strength values. Lai *et al.* have suggested that the reduction in bond strength in hydrogen-peroxide-treated dentin could be caused by residual solution in the collagen matrix and dentinal tubules that occasionally broke down to oxygen and water. Liberation of oxygen could either interfere with resin infiltration into etched dentin, or inhibit polymerization of resins.[18]

Carbamide peroxide did not interfere in the adhesion of composite resin with dentin. The reaction of carbamide peroxide is immediate and probably the residues of hydrogen peroxide leach rapidly[8], sodium perborate releases less hydrogen peroxide and has a slower process.[4]

Furthermore, dentin is a porous substrate and the peroxide residues of CP could release the oxygen more easily to the dentin tubules than to enamel. Nakamichi *et al.* demonstrated that bovine coronal dentin possessed larger dentin tubules.[33] Therefore, the bovine dentin is more porous and the peroxide residues could spread more easily than in human dentin.

Mechanical properties of dentin vary with distance from the pulp.[34,35] The effect of the bleaching agent is likely to be more pronounced in the inner dentin, decreasing as it approaches the dentinoenamel or dentinocemental junction.[34] In this study only the outer dentin was evaluated. The specimens were polished to obtain a flat outer dentin surface. This procedure could have removed residues of hydrogen peroxide and decreased the action of bleaching agent on bonding strength.

According to the Chng *et al.* the variation bleaching agent effect concerning the dentin location is likely to be related to several factors, such as the pH of the bleaching agents, the buffering capacity of dentin, and the increasing diameter and density of dentinal tubules near the pulp.[34]

Another study in our laboratory[3] stated that nonvital bleaching increase the microleakage on restorations with dentin margins, but not with enamel margins. It should be emphasized that the methods of work for bleaching/adhesion present in the literature have differences that may interfere in the results obtained, such as the concentration of the bleaching agent, the technique of bleaching treatment, the preparation of the substrate, the enamel or dentin substrate, the period of bleaching, the test used, and the performance of the restoration.

Even with these differences, the studies have demonstrated that restoration procedures performed after bleaching require caution. Several studies have confirmed that the composite resin restoration performed immediately after bleaching treatment results in shear bond strength decrease on enamel[12,16,17,19,21-24] and dentin[11,13,18,20]shear bond strength.

This study showed that the type of adhesive system did not affect the shear bond strength values in bleached teeth. The use of water/alcohol and acetone-based adhesive systems may not reverse the effects of bleaching treatment on bond strengths. Some researchers have found that *in vitro* specimens stored in water or artificial saliva suffer a complete reversal of the reduce enamel bonds.[13,14,18] This seems to be due to the leaching of hydrogen peroxide into the water. Therefore, the decrease on shear bond strength values on bleached tooth is time dependent. A delay in bonding procedures for composite resin restoration is recommended.[12,13,24,30]

a. KG Sorensen, Barueri, SP, Brazil.

b. Metalúrgica Fava, Franco da Rocha, SP, Brazil.

c. Kavo do Brasil S/A, Joinville, SC, Brazil.

d. Dentsply, Petrópolis, Rio de Janeiro, Brazil.

e. Araldite Ciba Especialidades Química, Taboão da Serra, SP, Brazil.

f. Proderma Farmácia de Manipulação Ltda, Piracicaba, SP, Brazil.

g. Super Endo Whiteness - FGM Produtos Odontológicos, Joinville, SC, Brazil.

h. Piraglass, Piracicaba, SP, Brazil.

i. Maxigrind, Solotest, São Paulo, SP, Brazil.

j. Carborundum Abrasivos, Recife, PE, Brazil.

k. 3M Dental Products, St Paul, USA.

l. Kuraray, Osaka, Japan.

m. Optilux 500/Demetron-Kerr, Danbury, CT, USA.

n. Emic DL-500, São José dos Pinhais, SP, Brazil.

REFERENCES

1.Baratieiri LN, Ritter AV, Monteiro Jr S, Caldeira de Andrade MA, Vieira LCC. Nonvital tooth bleaching: guidelines fo the clinician. Quintessence Int 1996;26:597-608.

2.Toko T, Hisamitsu H. Shear bond strength of composite resin to unbleached and bleached human dentine. Asia J Aesthetic Dent 1993;1:33-36.

3.Haywood VB. History, safety, and effectiveness of current bleaching techniques and applications of the nightguard vital bleaching technique. Quintessence Int 1992;23:471-488.

4.Shinohara MS, Rodrigues JA, Pimenta LAF. In vitro microleakage of composite restorations after nonvital bleaching. Quintessence Int 2001;32:413-417.

5.Rotstein I, Lehr Z, Gedalia I. Effect of bleaching agents on inorganic components of human dentin and cementum. J Endod 1992;18:290-293.

6.Hara AT, Pimenta LAF. Nonvital tooth bleaching: a 2-year case report. Quintessence Int 2000;30:748-754.

7.Weiger R, Kuhn A, Löst C. Radicular penetration of hydrogen peroxide during intra-coronal bleaching with various forms of sodium perborate. In Endod J 1994;27:313-317.

8.Barreiros ID, Alves MAG, Dutra PMM, Mendonça LL, Ferreira LCN. Tratamento clareador com peróxido de carbamida whiteness super endo (FGM) a 37% em dentes não-vitais – uma técnica. JBD 2002;1:140-145.

9.Ernst C-P, Marroquín BB, Willershausen-Zönnchen B. Effects of hydrogen peroxide-containing bleaching agents on the morphology of human enamel. Quintessence Int 1996;27:53-56.

10.Crim GA. Prerestorative bleaching: effect on microlekage of class V cavities. Quintessence Int 1992;23:823-825.

11.Titley KC, Torneck CD, Smith DC, Cherneck R, Adibfar A. Scanning electron microscopy observations on the penetration and structure of resin tags in bleached and unbleached bovine enamel. J Endod 1991;17:72-75.

12.Cavalli V, Reis AF, Giannini M, Ambrosano GMB. The effect of elapsed time following bleaching on enamel bond strength of resin composite. Oper Dent 2001;26:597-602.

13.Demarco FF, Turbino ML, Jorge AG, Matson E. Influence of bleaching on dentin bond strength. Am J Dent 1998;11:78-82.

14.Torneck CD, Titley KC, Smith DC, Adibfar A. Effect of water leaching on the adhesion of composite resin to bleached and unbleached bovine enamel. J Endod 1991;17:156-160.

15.Sung EC, Chan SM, Mito R, Caputo AA. Effect of carbamide peroxide bleaching on the shear bond strength of composite to dental bonding agent enhanced enamel. J Prosthet Dent 1999;82:595-599.

16.Barkhordar RA, Pontejos J, Machado S, Watanabe LG. The effect of a bleaching agent on leakage of composite resin. J Dent Res (abst 2437):570.

17.Titley KC, Torneck CD, Ruse ND, Krmec D. Adhesion of a resin composite to bleached and unbleached human enamel. J Endod 1993;19:112-115.

18.Lai SCN, Mak YF, Cheung GSP, Osorio R, Toledano M, Carvalho RM, Tay FR, Pashley DH. Reversal of compromised bonding to oxidized etched dentin. J Dent Res 2001;80:1919-1924.

19.Titley KC, Torneck CD, Smith DC, Adibfar A. Adhesion of composite resin to bleached and unbleached bovine enamel. J Dent Res 1988;67:1523-1528.

20.Spyrides GM, Perdigão J, Pagani C, Araújo MAM, Spyrides SMM. Effect of whitening agents on dentin bonding. J Esthet Dent 2000;12:264-270.

21.Stokes AN, Hood JAA, Dhariwal D, Patel K. Effect of peroxide bleaches on resin-enamel bonds. Quintessence Int 1992;23:769-771.

22.Lai SCN, Tay FR, Cheung GSP, Mak, YF, Carvalho RM, Wei SHY, Toledano M, Osorio R, Pashley DH. Reversal of compromised bonding in bleached enamel. J Dent Res 2002;81:477-481.

23.Torneck CD, Titley KC, Smith DC, Adibfar A. The influence of time of hydrogen peroxide exposure on the adhesion of composite resin to bleached bovine enamel. J Endod 1990;16:123-128.

24.Perdigão J, Francci C, Swift Jr EJ, Ambrose WW, Lopes M. Ultra-morphological study of the interaction of dental adhesives with carbamida peroxide-bleached enamel. Am J Dent 1998;11:291-301.

25.Kalili KT, Caputo AA, Mito R, Sperbeck G, Matyas J. In vitro toothbrush abrasion and bond strength of bleached enamel. Pract Periodontics Aesthet Dent 1991;3:22-24.

26.Kalili KT, Caputo AA, Yoshida K. Effect of alcohol pretreatment on composite bond strength to bleached enamel. J Dent Res 1993;72 (abst 1440):283.

27.Al-Ehaideb A, Mohammed H. Shear bond strength of "one bottle" dentin adhesives. J Prosthet Dent 2000;84:408-412.

28.Barkhordar RA, Kempler D, Plesh O. Effect of nonvital tooth bleaching on microleakage of resin composite restorations. Quintessence Int 1997;28:341-344.

29.Josey AL, Meyers IA, Romaniuk K, Symons AL. The effect of a vital bleaching technique on enamel surface morphology and the bonding of composite resin to enamel. J Oral Rehab 1996;23:244-250.

30.García-Godoy F, Dodge WW, Donohue M, O'Quinn. Composite resin bond strength after enamel bleaching. Oper Dent 1993;18:144-147.

31.Rotstein I, Dankner E, Goldman A, Heling I, Stabholz A, Zalkind M. Histochemical analysis of dental hard tissues following bleaching. J Endod 1996;22:23-26.

32.Perinka L, Sano H, Hosoda H. Dentin thickness, hardness, and Ca-concentration vs bond strength of dentin adhesives. Dent Mater 1992;8:229-233.

33.Nakamichi M, Iwaku M, Fusayama T. Bovine teeth as possible substitutes in the adhesion test. J Dent Res 1983;62:1076-1081.

34.Chng HK, Palamara JEA, Messer HH. Effect of hydrogen peroxide and sodium perborate on biomechanical properties of human dentin. J Endod 2002;28:62-67.

35.Pashley D, Okabe A, Parham P. The relationship between dentin microhardness and tubule density. Endod Dent Traumatol 1985;1:176-9.

Table 1. Application procedures of adhesive systems.

Adhesive System	**Procedures**
Single Bond (SB)	Etching (15s), rinse (15s), blot dry, apply adhesive in 2 consecutive coats, air thin gently (2-5s), light-cure (10s)
Clearfil SE Bond (CLF)	Light air drying, apply Primer, wait 20s, evaporate with light air flow, apply Bond, gently air blow, light cure (10s)
Prime & Bond NT (PB)	Etching (15s), rinse (15s), blot dry, apply 1 coat of the adhesive, air thin gently (2-5s), light-cure (10s)

Table 2. Results of Two-way ANOVA and Tukey tests – enamel.

Enamel			
	Single Bond	**Clearfil SE Bond**	**Prime & Bond NT**
37% Carbamide Peroxide	20.23(6.30) B a	19.14(9.23) B a	11.93(5.74) B b
Sodium Perborate	16.56(5.96) B a	21.62(4.72) B a	10.92(5.10) B b
Control (no-treatment)	21.44(5.01) A a	23.69(5.73) A a	17.46(7.42) A b

Groups that were statistically different from each other are indicated by different capital letters (per columm) and small letters (per row).

Table 3. Results of Two-way ANOVA and Tukey tests – dentin.

Dentin			
	Single Bond	**Clearfil SE Bond**	**Prime & Bond NT**
37% Carbamide Peroxide	19.88(5.56) A a	18.54(6.20) A a	15.41(6.13) A b
Sodium Perborate	14.55(2.58) B a	18.41(4.69) B a	8.50(4.56) B b
Control (no-treatment)	19.09(3.30) A a	22.29(5.11) A a	11.40(4.58) A b

Groups that were statistically different from each other are indicated by different capital letters (per columm) and small letters (per row)

3.3 CAPÍTULO 4

Shear bond strength evaluation of composite resin on enamel and dentin after nonvital bleaching

(aceito para publicação na Journal of Esthetic and Restorative Dentistry)

CAPÍTULO 4

SHEAR BOND STRENGTH EVALUATION OF COMPOSITE RESIN ON ENAMEL AND DENTIN AFTER NONVITAL BLEACHING

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ABSTRACT

Background: studies have shown that bleaching agents interfere in adhesion of composite resin placed immediately after bleaching (AB). The aim of this study was to evaluate the shear bond strength (SBS) of composite resin after nonvital bleaching in four different times post-bleaching (1 day and 1, 2 and, 3 weeks).

Materials and Methods: two-hundred and seventy bovine teeth were assigned into 9 groups (n=30): G1-sodium perborate (SP)/1dayAB; G2-SP/1week (w)AB; G3-SP/2wAB; G4-SP/3wAB; G5-37% carbamide peroxide (CP)/1dayAB; G6-CP/1wAB; G7-CP/2wAB; G8-CP/3wAB; G9-control group (no treatment). After bleaching treatment, the teeth in each group were separated to enamel and to dentin. The teeth were cut, included in polyester resin, and polished to obtain a flat enamel and dentin surface. On each flat surface the adhesive system was applied and a cylinder of composite resin was bonded. The specimens were stored in distilled water for 7 days at 37°C. The SBS test was performed in a Universal Test Machine at a crosshead speed of 0.5 mm/min.

Results: the data, converted in Mpa, were subjected to ANOVA, Dunnett, Tukey, $p \leq 0.05$ and showed a statistically significant decrease in bond strengths of composite resin for enamel and dentin 1 day after the nonvital bleaching.

Clinical significance: The decrease in SBS values is time dependent. A delay in bonding procedures for composite resin restoration is recommended. According to the results, 2 weeks after bleaching is satisfactory time to perform the restoration of composite resin for both enamel and dentin.

INTRODUCTION

One of the factors that contributes most to the success or failure of a pleasant smile is the color of an isolated tooth or of the teeth as a whole.[1] Discoloration of nonvital teeth is an esthetic problem which frequently requires treatment.[2] Bleaching permits successful esthetic outcome while conserving tooth structure at minimal expense.[3]

Endodontic therapy occasionally has the undesired effect of darkening the treated tooth[4] Nonvital tooth bleaching has been shown to be an effective and conservative technique.[5] Thus, the bleaching treatment is an important phase of restorative procedure. This is an attempt to restore normal shade of a tooth by decolorizing the stain with an oxidizing agent.[6]

For nonvital tooth bleaching, a preparation of sodium perborate/water paste in the "walking bleach" technique has been the most popular and recommended one. Since the decomposition reaction of sodium perborate is slow and releases hydrogen peroxide in low concentration, it gives a wider margin of safety in relation to other techniques.[2,6,7,8] Another bleaching agent that could be used in the "walking bleach" technique is the 37% carbamide peroxide which has been used and considered a secure practice.[9,10]

Nonvital bleaching is often followed by the placement of esthetic restorations. Several studies have demonstrated the decrease in bond strengths of composite resin to bleached enamel and dentin after the bleaching process.[10,11,12,13,14,15]

The influence on bond strength may be due to an interaction between peroxide or peroxide-related substances and the resin at or near the enamel surface.[16] Nikaido et al. have suggested that reduction in bond strength in hydrogen peroxide treated dentin could be caused by residual solution in the collagen matrix and dentinal tubules that eventually broke down to oxygen and water.[17,18] Oxygen release could either interfere with resin infiltration into etched dentin and enamel, or inhibit polymerization of resins.[17,19]

However, Perdigão et al. has indicated that the residual oxygen may not be responsible for this effect. The changes in proteins and in mineral content of the most superficial layers of enamel may be responsible for the reduced bond strengths.[20]

Previous studies stated that the elapsed time after bleaching decreases the hydrogen peroxide adverse effects of bonding procedures.[5,11-13,19,21-23]

To achieve a good adhesion it is necessary to know the time that has elapsed from the bleaching treatment to the restoration procedure.[10] The purpose of this study was to evaluate the shear bond strength of a composite resin after nonvital bleaching in four different times post-bleaching (1 day and 1, 2 and, 3 weeks).

MATERIALS AND METHODS

Specimen preparation to bleaching treatment

Two-hundred and seventy freshly extracted bovine teeth were selected, cleaned, and stored in 0.1% thymol solution prior to the study. Each tooth was horizontally sectioned approximately 11 mm occlusally and 7 mm apically to the cemento-enamel junction using a double-faced diamond disk (KG Sorensen, Barueri, SP, Brazil). The pulp was removed with a dental probe, and the pulp chamber was enlarged to a standard size with a spherical diamond bur 1016HL (Metalúrgica Fava, Franco da Rocha, SP, Brazil) using a low-speed handpiece (Kavo do Brasil S/A, Joinville, SC, Brazil).

Bleaching treatment

A 3-mm thick base material (Cavitec-DentalTEC, Joinville, SC, Brazil) was placed in the root canal and leveled 2 mm below the cemento-enamel junction to prevent apical leakage of the bleaching material during the "walking bleach" technique.

The apical region was sealed with an adhesive system Single Bond (3M Dental Products, St Paul, USA) and composite resin Fill Magic (Vigodent, Bonsucesso, RJ, Brazil). The teeth were stored in a humidor at 37°C before bleaching treatment.

The specimens were randomly assigned into 9 groups (n=30), according to the bleaching treatment and the different post-bleaching times (Table 1). The control group was not bleached and stored in artificial saliva at 37°C before the restoration. The bleaching treatment was conducted considering different initial times so that all groups reached post-bleaching time simultaneously, allowing restorative procedure at the same stage.

The "walking bleach" technique was used to both bleaching agents sodium perborate (2g/1ml distilled water) (Proderma Farmácia de Manipulação Ltda, Piracicaba, SP, Brazil) and 37% carbamide peroxide gel (Super Endo Whiteness - FGM Produtos Odontológicos, Joinville, SC, Brazil). The bleaching materials were inserted in the pulp chamber, and a 1.5 mm thick surface seal was made with a temporary material Cavitec. The bleaching agents were changed every 7 days, for three weeks. The teeth were stored in artificial saliva at 37°C during the bleaching period.

Specimen preparation to shear bond strength test

After bleaching treatment, the specimens were sectioned and the fragments obtained were included in polyester resin (Piraglass, Piracicaba, SP, Brazil). The embedded specimens were polished on a water coolant mechanical grinder (Maxigrind, Solotest, São Paulo, SP, Brazil) using Al_2O_3 sandpapers (Carborundum Abrasivos, Recife, PE, Brazil) to expose flat surfaces areas of 5-6 mm^2. Half of the specimens of each group was ground to obtain a flat dentin surface and the other half was ground to obtain a flat enamel surface. After this, a 3 mm diameter area was left uncovered as a bonding site by placing a fenestrated PVC film with a 3 mm diameter hole over the flat surface (dentin and enamel).

Restorative procedures

Single Bond (3M Dental Products, St Paul, USA) adhesive system and Z-250 (3M Dental Products, St Paul, USA) composite resin were used according to the manufacturer's instructions to the bonding procedures.

A piece of tape with a hole (diameter of 3.0 mm) was attached to the specimen surface in all groups to limit the area of the bonded surface. The flat surface (enamel or dentin) was etched for 15 seconds with 35% phosphoric acid gel, rinsed with water for 15 seconds, and briefly dried leaving a moist surface. Two consecutive coats of the adhesive were applied, lightly air dried for 2 seconds, and light cured (Optilux 500/Demetron-Kerr, Danbury, CT, USA) for 10 seconds.

After application of the bonding agent, a bipartite Teflon ring mold with a circular hole 3.0 mm diameter and 5.0 mm deep was positioned over the treated flat surface (enamel or dentin). The mold was filled with composite resin and light cured for 40 seconds, then light cured again for an additional 40 seconds in opposite directions after removing the mold.

The specimens were immersed in distilled water and stored for one week at 37°C before testing.

Bond strength test

The shear bond strength was measured in a Universal Test Machine (Emic DL-500, São José dos Pinhais, SP, Brazil). A parallel knife-edge shearing device was aligned over the bonded interface and the specimen was loaded to failure using crosshead speed of 0.5 mm/min. Means and standard deviations were calculated and expressed in Mpa. The data were subjected to two-way ANOVA with an additional treatment (non treated-control group). Dunnett's test was applied to compare the treated groups with the control group, and Tukey test compared the bleaching agents used. The data of different times (1 day, 1, 2, and 3 weeks) were analyzed by polynomial regression ($\alpha=0.05$).

Figure 1

RESULTS

Mean bond strengths and standard deviations are shown in Table 2 and Table 3.

For enamel, the Dunnett's test showed a statistically significant decrease in bond strengths for G-1 ($p=0.03$), G-2 ($p=0.0007$), and G-5 ($p=0.004$) compared to the G-9 control group (no treatment). For dentin, the Dunnett's test showed a statistically significant decrease in bond strengths for the G-1 ($p=0.019$) compared to the G-9 control group (no treatment).

The results suggest that the bleaching treatment with sodium perborate and 37% carbamide peroxide interferes in adhesion of composite resin restoration for both enamel and dentin.

The Tukey test showed higher bond strength values for teeth bleached with 37% carbamide peroxide when compared to teeth bleached with sodium perborate for both enamel ($p=0.03$) and dentin ($p=0.001$)

The F test revealed a statistically significant difference among groups of different post bleaching times for both sodium perborate and 37% carbamide peroxide disregarding the substrate (enamel and dentin). The graphics of polynomial regression demonstrated a statistically significant difference among treated groups for both enamel ($p=0.00018$) and dentin ($p=0.00025$). (Figure 2)

For enamel, the results suggested that the 2 week period elapsed from the bleaching treatment (PS and PC) to restorative procedure does not reduce bond strengths compared with control group.

For dentin, the results suggested that the 1 week period elapsed from bleaching treatment with sodium perborate to restorative procedure does not reduce bond strengths, and the 37% carbamide peroxide agent does not interfere in shear bond strength values.

DISCUSSION

Nonvital bleaching treatment is a well accepted clinical procedure. An important and necessary step after bleaching is the esthetic restorative procedure. Several researches have demonstrated that bleaching reactions interfere in bond strength of adhesive systems and composite resins[5,11,12,14,15,19,21,22,24]. Shinohara et al. stated that nonvital bleaching increase the microleakage on dentin margins of composite resin restorations.[10]

The findings in this work have confirmed previous studies. [5,11,12,14,15,19,21,22,24] The bleaching treatment might alter the substrate and interfere in adhesion of composite resin restorations for both enamel and dentin. One of the hypothesis is that the presence of residual peroxides and oxygen could inhibit the polymerization process of the adhesive systems and adversely affect bond strengths.[14,25]

Our results have suggested that residual oxygen may be responsible for the decrease in bond strength. The bleaching agent was applied in the pulp chamber, showing that it is able to interfere in the substrate even at distance. The bleaching agent spreads from dentin to enamel. Conversely, Perdigão et al. found that the reduced bond strengths are due to the changes in the superficial layers of enamel.[20]

Another explanation is that the hydrogen peroxide has been suspected to cause denaturation of proteins in the organic components of dentin and enamel, altering the organic-inorganic ratio with an increase in inorganic component.[11]

According to the results obtained, the enamel substrate showed to be vulnerable to the bleaching reactions. The shear bond strength values were comparable to the control group (no treatment) after 2 weeks of bleaching treatment. In accordance to Josey et al. and García-Godoy et al., the characteristics of the etched enamel after bleaching seem altered and this may affect the bonding of composite resin to bleached enamel.[12,13]

Bovine teeth were used in the present study. If an interprismatic presence of peroxide is the explanation for the adverse influence on resin adhesion, it is highly likely that it may be more marked in bovine enamel than it is in human enamel, due to inherent differences in the structure and size of their interprismatic areas.[16]

Our data showed that after 2 weeks of elapsed time from bleaching treatment on enamel is sufficient to perform the restoration. Several studies have found that "in vitro" specimens stored in water or artificial saliva suffer a complete reversal of the reduced enamel bonds.[17,23]

This seems to be due to the leaching of hydrogen peroxide during the storage in artificial saliva after bleaching for both enamel and dentin. Demarco et al. reported that the increase of the adhesion in bleached teeth after the storage in distilled water. The hydrogen peroxide left on the dentin surface by bleaching treatment loses its activity with time because of its instability.[19]

As to dentin, the results showed that shear bond strength returns to the values similar to the control group 1 week after the bleaching treatment with sodium perborate. The 37% carbamide peroxide did not alter the shear bond strength of the adhesive system used. A possible justification for the results in dentin is that the porous substrate and the peroxide residues could release the oxygen more easily than in enamel substrate.

Another reason could be explained by the methodology of the present study which used the "walking bleach" technique. Different from the previous works where the specimens were immersed in bleaching agent[19] or the bleaching agent was placed on the ground dentin surface.[15] In our study, after the bleaching treatment was finished the specimens were polished to obtain a flat dentin surface. This procedure could alter the dentin surface and removed residues of hydrogen peroxide.

Furthermore, the reaction of carbamide peroxide is immediate and probably the residues of hydrogen peroxide leach rapidly,[9] while sodium perborate releases less hydrogen peroxide and has a slower process.[26] The difference between the releases of bleaching agents could explain the variation of results shown in several researches about the elapsed time between bleaching treatment and restorative procedure.

The present studies in the literature suggest that the bleaching treatment alters the bond strength in vital and nonvital teeth. The reduction in adhesion can also induce microleakage, that is the main cause of color reversal after the bleaching procedure.[19]

The decrease in shear bond strength values is time dependent. A delay in bonding procedures for composite resin restoration is recommended. According to the results, 2 weeks after bleaching is satisfactory to perform the restoration of composite resin.

CONCLUSIONS

- the decrease in shear bond strength values after nonvital bleaching is time dependent;

- 2 weeks after nonvital bleaching treatment is satisfactory to perform the restoration of composite resin for both enamel and dentin;
- teeth bleached using 37%carbamide peroxide showed higher SBS values than the ones bleached with sodium perborate.

ACKNOWLEDGMENTS

The authors would like to acknowledge the contributions of FGM Produtos Odontológicos, and the graduate student of Department of Restorative Dentistry (UNICAMP) Vanessa Gallego Arias for technical support. This study was supported by grant # 00/12975-6 from the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP).

REFERENCES

1.Baratieri LN, Ritter AV, Monteiro Jr S, Caldeira de Andrada MA, Vieira LCC. Nonvital tooth bleaching: guidelines for the clinician. Quintessence Int 1995;26:597-608.

2.Rotstein I, Mor C, Friedman S. Prognosis of intracoronal bleaching with sodium perborate preparations in vitro: 1-year study. J Endod 1993;19:10-12.

3.Haywood VB. Achieving, maintaining, and recovering successful tooth bleaching. J Esthet Dent 1996;8:31-38.

4.Lorenzo JA, Gumbau GC, Sánchez CC, Navarro LF. Clinical study of a halogen light-activated bleaching agent in nonvital teeth: case reports. Quintessence Int 1996;27:383-388.

5.Cavalli V, Reis AF, Giannini M, Ambrosano GMB. The effect of elapsed time following bleaching on enamel bond strength of resin composite. Oper Dent 2001;26:597-602.

6.Freccia WF, Peters DD, Lorton L, Bernier WE. An in vitro comparison of nonvital bleaching techniques in the discolored tooth. J Endod 1982;8:70-77.

7.Hara AT, Pimenta LAF. Nonvital tooth bleaching: a 2-year case report. Quintessence Int 2000;30:748-754.

8.MacIsaac AM, Hoen CM. Intracoronal bleaching: concerns and considerations. Scientific. J Can Dent Assoc 1994;60:57-64.

9.Barreiros ID, Alves MAG, Dutra PMM, Mendonça LL, Ferreira LCN. Tratamento clareador com peróxido de carbamida whiteness super endo (FGM) a 37% em dentes não-vitais – uma técnica. JBD 2002;1:140-145.

10.Shinohara MS, Rodrigues JA, Pimenta LAF. In vitro microleakage of composite restorations after nonvital bleaching. Quintessence Int 2001;32:413-417.

11.Barkhordar RA, Kempler D, Plesh O. Effect of nonvital tooth bleaching on microleakage of resin composite restorations. Quintessence Int 1997;28:341-344.

12.García-Godoy F, Dodge WW, Donohue M, Q'Quinn JA. Composite resin bond strength after enamel bleaching. Oper Dent 1993;18:144-147.

13.Josey AL, Meyers IA, Romaniuk K, Symons AL. The effect of a vital bleaching technique on enamel surface morphology and the bonding of composite resin to enamel. J Oral Rehab 1996;23:244-250.

14.Titley KC, Torneck CD, Smith DC, Adibfar A. Adhesion of composite resin to bleached and unbleached bovine enamel. J Dent Res 1988;67:1523-1528.

15.Toko T, Hisamitsu H. Shear bond strength of composite resin to unbleached and bleached human dentine. Asia J Aesthetic Dent 1993;1:33-36.

16.Torneck CD, Titley KC, Smith DC, Adibfar A. The influence of time of hydrogen peroxide exposure on the adhesion of composite resin to bleached bovine enamel. J Endod 1990;16:123-128.

17.Lai SCN, Mak YF, Cheung GSP, Osorio R, Toledano M, Carvalho RM, Tay FR, Pashley DH. Reversal of compromised bonding to oxidized etched dentin. J Dent Res 2001;80:1919-1924.

18.Nikaido T, Takano Y, Sasafuchi Y, Burrow MF, Tagami J. Bond strengths to endodontically-treated teeth. Am J Dent 1999;12:177-180.

19.Demarco FF, Turbino ML, Jorge AG, Matson E. Influence of bleaching on dentin bond strength. Am J Dent 1998;11:78-82.

20.Perdigão J, Francci C, Swift Jr EJ, Ambrose WW, Lopes M. Ultra-morphological study of the interaction of dental adhesives with carbamida peroxide-bleached enamel. Am J Dent 1998;11:291-301.

21.Spyrides GM, Perdigão J, Pagani C, Araújo MAM, Spyrides SMM. Effect of whitening agents on dentin bonding. J Esthet Dent 2000;12:264-270.

22.Titley KC, Torneck CD, Ruse ND, Krmec D. Adhesion of a resin composite to bleached and unbleached human enamel. J Endod 1993;19:112-115.

23.Torneck CD, Titley KC, Smith DC, Adibfar A. Effect of water leaching on the adhesion of composite resin to bleached and unbleached bovine enamel. J Endod 1991;17:156-160.

24.Stokes AN, Hood JAA, Dhariwal D, Patel K. Effect of peroxide bleaches on resin-enamel bonds. Quintessence Int 1992;23:769-771.

25.Titley KC, Torneck CD, Smith DC, Cherneck R, Adibfar A. Scanning electron microscopy observations on the penetration and structure of resin tags in bleached and unbleached bovine enamel. J Endod 1991;17:72-75.

26.Haywood VB. History, safety, and effectiveness of current bleaching techniques and applications of the nightguard vital bleaching technique. Quintessence Int 1992;23:471-488.

Table 1

GROUPS (N=30)	BLEACHING TREATMENT/POST-BLEACHING TIMES
G1	Sodium perborate / 1 day
G2	Sodium perborate / 1 week
G3	Sodium perborate / 2 weeks
G4	Sodium perborate / 3 weeks
G5	37% Carbamide peroxide / 1 day
G6	37% Carbamide peroxide / 1 week
G7	37% Carbamide peroxide / 2 weeks
G8	37% Carbamide peroxide / 3 weeks
G9	No treatment / control group

Table 2

	Enamel	
	Perborate	Carbamide
1 day	14.96(2.62)* B	16.48(4.46)* A
1 week	16.65(3.36)* B	18.60(3.85) A
2 weeks	19.12(2.98) B	20.00(3.58) A
3 weeks	18.47(4.35) B	20.65(5.26) A
control	20.07(3.39)	

* indicates the statistical difference with the control group for both enamel and dentin.

Statistical differences between bleaching agents are expressed by different letters in rows.

Table 3

	Dentin	
	Perborate	Carbamide
1 day	11.49(3.09)* b	13.98(4.85) a
1 week	15.98(3.45) b	18.03(2.93) a
2 weeks	14.41(4.14) b	19.04(4.75) a
3 weeks	15.88(5.29) b	16.98(5.44) a
control	16.99(6.80)	

* indicates the statistical difference with the control group for both enamel and dentin.

Statistical differences between bleaching agents are expressed by different letters in rows.

Figure 1

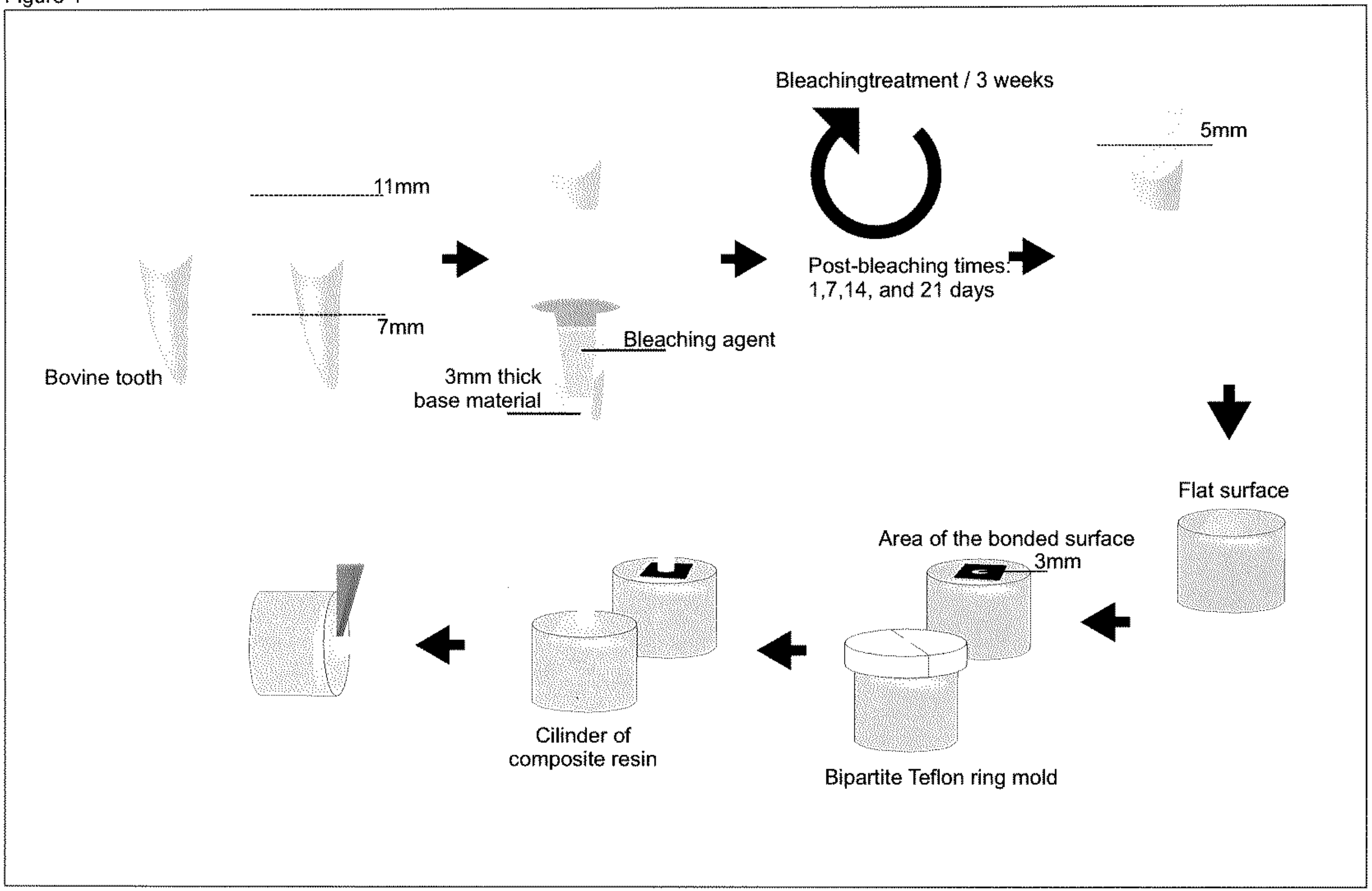
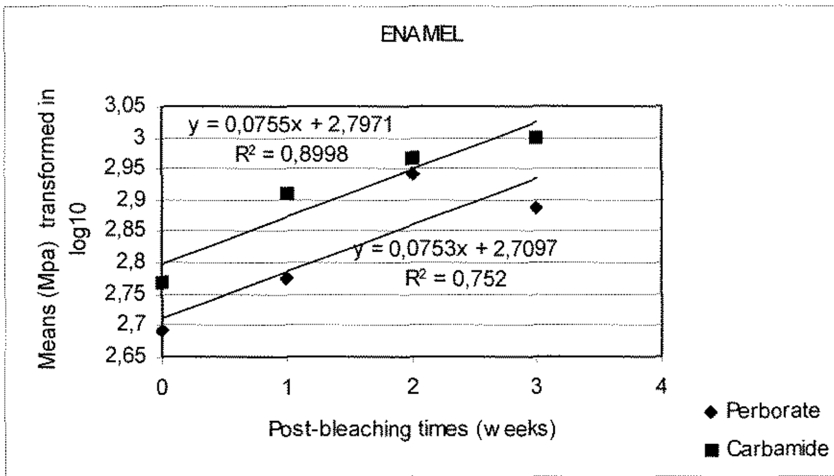
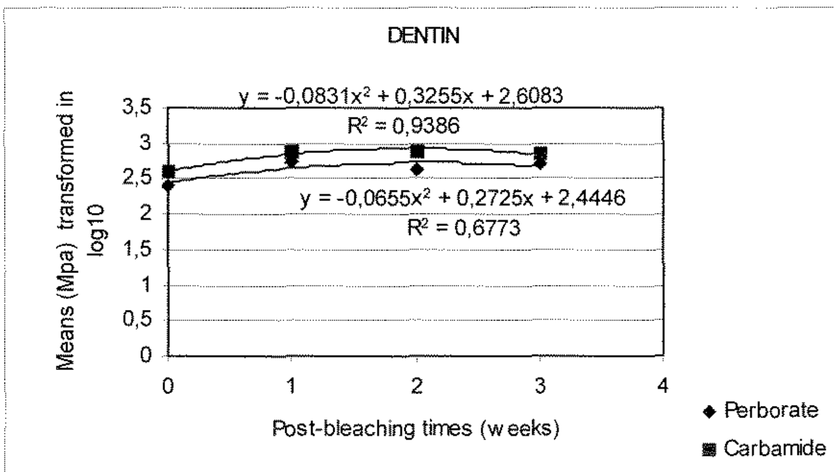


Figure 1

Figure 2


ENAMEL
Means (Mpa) transformed in log10
3,05
3
2,95
2,9
2,85
2,8
2,75
2,7
2,65
y = 0,0755x + 2,7971
R² = 0,8998
y = 0,0753x + 2,7097
R² = 0,752
0
1
2
3
4
Post-bleaching times (w eeks)
Perborate
Carbamide


DENTIN
Means (Mpa) transformed in log10
3,5
3
2,5
2
1,5
1
0,5
0
y = -0,0831x² + 0,3255x + 2,6083
R² = 0,9386
y = -0,0655x² + 0,2725x + 2,4446
R² = 0,6773
0
1
2
3
4
Post-bleaching times (w eeks)
Perborate
Carbamide

Legends

Table 1. Groups according to the bleaching agent and post-bleaching times.

Table 2. Shear bond strength mean values (standard deviations) in Mpa - enamel.

Table 3. Shear bond strength mean values (standard deviations) in Mpa - dentin.

Figure 1. Scheme.

Figure 2. Polynomial regression to the post-bleaching times for enamel and dentin.

CONSIDERAÇÕES

Estudos têm mostrado que o tratamento clareador, em dentes vitais ou não vitais, interfere na adesão de restaurações de resinas compostas realizadas imediatamente após o procedimento clareador. Os resultados apresentados anteriormente nos capítulos 2, 3 e 4 confirmam os dados presentes na literatura (TITLEY *et al.*, 1988; TORNECK *et al.*, 1990; TITLEY *et al.*, 1991; CRIM, 1992; TOKO & HISAMITSU, 1993; DISHMAN *et al.*, 1994; BARKHORDAR *et al.*, 1997; CAMPOS, 1998; PERDIGÃO *et al.*, 1998).

Conforme o capítulo 2, o tratamento clareador com pasta de perborato de sódio mais água ou com gel de peróxido de carbamida a 37% levou ao aumento do grau de microinfiltração em restaurações de resina composta realizadas 24 horas após o procedimento clareador, nas margens em dentina. Nas margens em esmalte, não houve aumento significativo dos valores de infiltração, quando comparados aos valores do grupo controle, não clareado.

Nos capítulos 3 e 4, os espécimes foram submetidos aos mesmos agentes clareadores utilizando a mesma técnica *walking bleach*, ou seja, o mesmo método de tratamento clareador do capítulo 2, diferindo quanto ao teste de adesão aplicado. No capítulo 3 foram avaliados três diferentes sistemas adesivos (a base de acetona ou etanol/água), partindo do conceito de estudos anteriores que a aplicação de adesivos a base de acetona, podem promover a interação do solvente com o oxigênio residual, neutralizando resíduos de água e oxigênio dos agentes clareadores, dispensando o tempo de espera pós clareamento para realizar o procedimento restaurador.

Os resultados do capítulo 3 mostraram não haver interação entre o tipo de sistema adesivo utilizado e o tratamento clareador, indicando que o clareamento não vital diminui a resistência adesiva independente do tipo de adesivo aplicado. Assim, o tratamento com perborato de sódio ou com peróxido de carbamida a 37% diminuiu a resistência adesiva no esmalte, enquanto que à dentina, apenas o perborato de sódio reduziu os valores de adesão.

O perborato de sódio e o peróxido de carbamida a 37% apresentam efeitos menos prejudiciais, quando comparados aos efeitos causados pelo peróxido de hidrogênio a 30-35%. O perborato de sódio é uma substância estável, em contato com a água se decompõe em metaborato e peróxido de hidrogênio, apresentando uma reação lenta com menor concentração de peróxido de hidrogênio. O peróxido de carbamida a 37%, por apresentar uréia nos componentes de sua decomposição, tem pH neutro ou próximo a neutro, e assim é um agente menos danoso à superfície dental.

O fato do peróxido de carbamida a 37% não ter interferido nos valores de adesão, pode estar relacionado à liberação mais rápida dos resíduos de oxigênio da dentina quando comparado ao perborato de sódio, que possui uma reação lenta. Além disso, a superfície de dentina foi desgastada para a obtenção de uma superfície plana. Nesta etapa, os resíduos de oxigênio presentes na superfície podem ter sido eliminados com mais facilidade do que na superfície de esmalte, por ser um substrato mais poroso.

Diante das informações obtidas nos estudos dos capítulos 2 e 3, foi delineado o trabalho citado no capítulo 4, no qual foram avaliados 4 tempos de espera pós clareamento (1, 7, 14 e 21 dias) para a realização do procedimento restaurador.

Os resultados mostraram que 7 dias de espera após o clareamento foi suficiente para se realizar uma restauração de resina composta em dentina. Em esmalte, a espera necessária foi de 14 dias. Portanto, duas semanas de espera após a finalização do clareamento dental interno é satisfatório para a execução do procedimento restaurador.

Em vista dos trabalhos realizados, observou-se que os agentes clareadores podem interferir na adesão da resina composta ao dente clareado, dependendo do substrato avaliado (esmalte ou dentina), do teste aplicado (cisalhamento ou microinfiltração) e do tempo de espera pós clareamento (1, 7, 14 e 21 dias) para a confecção das restaurações. O tempo de espera pós clareamento permite que os valores de união da resina composta ao dente sejam restabelecidos, próximos aos dos espécimes não submetidos ao clareamento.

É importante ressaltar os diferentes métodos utilizados nos trabalhos citados na literatura (TITLEY *et al.*, 1988; TORNECK *et al.*, 1990; TITLEY *et al.*, 1991; CRIM, 1992; TOKO & HISAMITSU, 1993; DISHMAN *et al.*, 1994; BARKHORDAR *et al.*, 1997; CAMPOS, 1998; PERDIGÃO *et al.*, 1998). Embora grande parte dos trabalhos mostre que o tratamento clareador, de alguma forma, influencia na união dente/restauração. Algumas diferenças entre os estudos implicam em prováveis variações nos resultados.

Diferenças quanto às concentrações de peróxido de hidrogênio presentes nos agentes clareadores é um fator importante, uma vez que a ação do peróxido de hidrogênio a 30-35% é mais intensa do que a do peróxido de carbamida a 10% e o perborato de sódio. O tempo e a forma de aplicação dos agentes clareadores também influenciam na quantidade de resíduos liberados pelo peróxido de hidrogênio. A intensidade da ação dos agentes clareadores difere dependendo do local de sua aplicação, superfície dental planificada ou câmara pulpar.

Além disso, os tipos de testes utilizados para a avaliação da adesão são diferentes. Dentes clareados, submetidos a testes mecânicos, podem apresentar valores de adesão reduzidos, e quando submetidos ao teste de microinfiltração, não apresentam diferenças significantes em relação ao grupo dos não clareados. Essas diferenças implicam numa avaliação detalhada dos diversos estudos, levando em consideração todos os fatores que podem interferir nos resultados finais encontrados. (TITLEY *et al.*, 1988; TORNECK *et al.*, 1990; TITLEY *et al.*, 1991; CRIM, 1992; TOKO & HISAMITSU, 1993; DISHMAN *et al.*, 1994; BARKHORDAR *et al.*, 1997; CAMPOS, 1998; PERDIGÃO *et al.*, 1998)

Para trabalhos *in vitro* de adesão em dentes submetidos ao clareamento, o método utilizado tem grande importância, uma vez que a ação do agente clareador é o principal fator, assim como o substrato avaliado. Esses trabalhos laboratoriais são extremamente importantes para o conhecimento e aprimoramento clínico do material, assim como seu desempenho no substrato dental juntamente com outros materiais.

Diante dos resultados obtidos neste estudo, a adesão ao substrato clareado está comprometida se realizada imediatamente após o término do tratamento clareador. Segundo vários autores, resíduos de peróxido e o oxigênio liberado pela reação dos agentes clareadores podem inibir a polimerização da resina composta, impedindo adesão adequada, promovendo falhas na adesão e conseqüentemente comprometendo a longevidade da restauração, assim como o da estética. Muitos estudos também indicam, como conseqüência, uma alteração nos componentes químicos do substrato dental.

O clareamento dental interno, se aplicado com cautela, é uma alternativa muito eficaz no tratamento de dentes escurecidos tratados endodonticamente. A técnica *walking bleach* é considerada prática e segura, sendo a mais recomendada nos dias atuais. Ao final de todo tratamento clareador deve-se aguardar um período pós clareamento para se realizar as restaurações de resina composta. Segundo os dados obtidos, um período de 14 dias é suficiente para que subprodutos dos agentes clareadores não interfiram na adesão da restauração tanto em esmalte quanto em dentina.

CONCLUSÃO

Diante dos 4 capítulos deste trabalho, pode-se concluir que:

(1) O clareamento dental interno, com perborato de sódio ou peróxido de carbamida a 37% utilizando a técnica *walking bleach,* é considerada uma alternativa eficaz e segura, se aplicada com cautela.

(2) O tratamento clareador pode interferir na adesão da resina composta ao dente, dependendo do substrato (esmalte ou dentina) e do teste avaliado (microinfiltração ou cisalhamento).

(3) O tipo de sistema adesivo avaliado não influenciou nos valores de adesão dos dentes submetidos ao tratamento clareador. Independente do sistema adesivo aplicado, a resistência adesiva após o clareamento foi menor em relação ao do grupo não clareado, dependendo do substrato e do agente clareador.

(4) Após o término do tratamento clareador, deve-se aguardar um período de 14 dias para se realizar o procedimento restaurador definitivo, tanto em esmalte como em dentina, diminuindo os possíveis danos dos subprodutos dos agentes clareadores na adesão da resina composta ao substrato dental.

REFERÊNCIAS BIBLIOGRÁFICAS*

BARATIERI, L.N. *et al.*. Clareamento Dental. 1.ed. São Paulo: Quintessence Editora, 1993.

BARKHORDAR, R.A.; KEMPLER, D.; PLESH, O. Effect of nonvital tooth bleaching on microleakage of resin composite restorations. Quintessence Int, Berlim, v.28, n.5, p.341-344, May1997.

CREWS, K.M. *et al.* Whitening Obtained Using 10% Carbamide Peroxide with Varied Exposure Times. J Dent Res, Washington, v.71, p.282 1992 (abstr.1411).

CRIM, G.A. Prerestorative bleaching: effect on microleakage of Class V cavities. Quintessence Int, Berlim, v.23, n.12, p.823-825, Dec.1992.

DE DEUS, Q.D. Endodontia. 5ed. Rio de Janeiro, Editora Médici1992, 383p.

DISHMAN, M.V.; COVEY, D.A.; BAUGHAN, L.W. The effects of peroxide bleaching on composite to enamel bond strength. Dent Mat, Washington, v.10, n.1, p.33-36, Jan.1994.

FRECCIA, W.F *et al.* An in vitro comparison of nonvital bleaching techniques in the discolored tooth. J. Endodon, v.8,n.2, p.70-77, Feb.1982.

HARA, A.T.; PIMENTA, L.A.F. Nonvital tooth bleaching: A 2-year case report. Quintessence Int, Berlim,v.30, n.11, p.748-754, Nov.1999.

HARRINGTON, G.W.; NATKIN, E. External resorption associated with bleaching of pulpless teeth. J Endodon, v. 5, n.11, p.344-348, Nov.1979.

HAYWOOD, V.B. History, safety, and effectiveness of current bleaching techniques and applications of the nightguard vital bleaching technique. Quintessence int, Berlim, v.23, n.7, p.471-488, July1992.

HO, S.; GOERIG, A.C. An In Vitro Comparison of Different Bleaching Agents in the Discolored Tooth. J Endodon, v.15, n.3, p.106-111, Mar.1989.

LADO, E.A.; STANLEY, H.R.; WEISMAN, M.I. Cervical resorption in bleached teeth. Oral Surg Oral Med Oral Path, v.55, n.1, p.78-80, Jan.1983.

LEONARD, R.H.; SHARMA, A.; HAYWOOD, V.B. Use of different concentrations of carbamide peroxide for bleaching teeth: An in vitro study. Quintessence Int, Berlim, v.29, n.8, p.503-507, Aug.1998.

MACLSAAC, A.M.; HOEN , M.M. Intracoronal Bleaching: Concerns and Considerations. J Can Dent Assoc, v.60, n.1,p. 57-64, Jan.1994.

NAKAMICHI, I.; IWAKU, M.; FUSAYAMA, T. Bovine Teeth as Possible Substitutes in the Adhesion Test. J Dent Res, Washington, v.62, n.10, p.1076-1081, Oct.1983.

CAMPOS, I.C. Avaliação qualitativa da microinfiltração em restaurações de resina composta substituídas após o clareamento com gel de peróxido de carbamida. Piracicaba, 1998. Dissertação (Mestrado em Dentística) – Faculdade de Odontologia de Piracicaba, Universidade Estadual de Campinas.

PERDIGÃO, J. *et al.* Ultra-morphological study of the interaction of dental adhesives with carbamide peroxide-bleached enamel. Am J Dent, San Antonio, v.11, n.6, p.291-301, Dec.1998.

REEVES, G.W. *et al.* Microleakage of New dentin Bonding Systems Using Human and Bovine Teeth. Oper Dent, v.20, p.230-235, Nov.-Dec.1995.

RODRIGUES, J.A.; PIMENTA, I.C.; PIMENTA, L.A.F. Clareamiento No Vital: Revisión de la Literatura. Rev Fola/Oral, v.VI, n.17, Jan.-Jun.2000.

ROTSTEIN, I.; MOR, C.; FRIEDMAN, S. Prognosis of Intracoronal Bleaching with Sodium Perborate Preparations In Vitro: 1-Year Study. J. Endod., v.19, n.1, p.10-12, Jan.1993.

STOKES, A.N. *et al.* Effect of peroxide bleaches on resin-enamel bonds. Quintessence Int, Berlim, v.23, n.11, p.769-771, Nov.1992.

TITLEY, K.C. *et al.* Adhesion of Composite Resin to Bleached and Unbleached Bovine Enamel. J Dent Res, Washington, v.67, n.2, Dec.1988.

TITLEY, K.C. *et al.* Scanning electron microscopy Observations on the Penetration and Structure of Resin Tags in Bleached and Unbleached Bovine Enamel. J Endod, v.17, n.2, Feb.1991.

TOKO, T.; HISAMITSU, H. Shear bond strength of composite resin to unbleached and bleached human dentine. Asia J Aesthet Dent, v.1,n.1, p.33-36, Jan. 1993.

TORNECK, C.D. *et al.* The Influence of Time of Hydrogen Peroxide Exposure on the Adhesion of Composite Resin to Bleached Bovine Enamel. J Endod, v.16, n.3, Mar.1990.

WARREN, M.A.; WONG, M.; INGRAM, T.A. An In Vitro Comparison of Bleaching Agents on the Crowns and Roots of Discolored Teeth. J Endod, v.16, n.10, Oct.1990.

* Referências de acordo a NBR-6023, Agosto de 2000, da Associação Brasileira de Normas Técnicas.

ANEXOS

Sem nunca falhar um exemplar

Porto Alegre, 26 de agosto de 2002.

Ilmo. Sr
Prof. Dr. Luiz André Freire Pimenta

Prezado colega,

Recebemos e agradecemos envio de seu trabalho para ser publicado na RGO.

Assim que editado, lhe enviaremos comunicação a respeito.

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Journal of Esthetic and Restorative Dentistry

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March 5, 2003

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Dear Dr. ~~Pimenta~~ Luiz:

I am pleased to inform you that your manuscript entitled, "Shear Bond Strength evaluation of composite resin on enamel and dentin After Nonvital Bleaching" has been accepted for publication in the *Journal of Esthetic and Restorative Dentistry* pending minor editing. Please find a list of suggestions that will help guide your final edits. Once you have addressed these concerns, please return your manuscript as soon as possible to ensure timely publication of the manuscript. For reference purposes, the Tracking Number for your manuscript is: #090202. If the submission is incomplete or deficient in any areas (e.g. missing abstract, legends, etc.), our Editorial Assistant, Ms. Betty Cates will contact you. If you have any questions regarding the status of your manuscript at any time following re-submission, please feel free to contact us.

I really appreciate your submitting this manuscript for our review. Only through the submission of high quality manuscripts can we hope to maintain a high standard of excellence for the *Journal of Esthetic and Restorative Dentistry*, making it the pre-eminent publication in the field of esthetic dentistry. We look forward to receiving your final manuscript soon.

Sincerely,

Thanks Luiz!

Harald O. Heymann, D.D.S., M.Ed.
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Enclosure

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In vitro microleakage of composite restorations after nonvital bleaching

Mirela Sanae Shinohara, DDS[1]/José Augusto Rodrigues, DDS[2]/Luiz André Freire Pimenta, DDS, ScD[3]

Objective: After bleaching treatment, esthetic restorations often need to be replaced due to color changes. Some papers have shown alterations in the bond of adhesive restorations to bleached teeth. The purpose of this study was to evaluate tooth and resin composite adhesion when submitted to nonvital dental bleaching. **Method and materials:** One hundred and twenty bovine teeth were assigned to 3 groups (n = 40): paste of sodium perborate and water; 37% carbamide peroxide gel; and no bleaching (control). After 3 weeks of continuous bleaching treatment, standardized Class V cavities were prepared at the cementoenamel junction and restored with Single Bond adhesive system and Z100 resin composite. The samples were thermocycled 1,500 times (5 ± 1 / 55 ± 1°C) with a 1-minute dwell time. Then, they were immersed in a 2% methylene blue solution (pH 7) for 4 hours, sectioned, and analyzed by stereomicroscopy. Microleakage analyses were done, using scores from 0 to 4, considering leakage on the incisal wall (enamel) and the cervical wall (dentin). Data were analyzed by Kruskal-Wallis and Mann-Whitney tests ($\alpha = 0.05$). **Results:** The results showed that sodium perborate and carbamide peroxide gel significantly increase the microleakage in Class V resin composite restorations to dentin but not to enamel margins. **Conclusion:** The risk of microleakage in dentin margins is increased soon after bleaching treatment.
(Quintessence Int 2001;32:413–417)

Key words: bleaching agents, discolored tooth, microleakage, nonvital tooth, tooth bleaching, walking bleach

CLINICAL RELEVANCE: After nonvital bleaching with either sodium perborate and water or 37% carbamide peroxide, the seal of new resin composite restorations is jeopardized, resulting in increased microleakage of dentin margins.

Discolored anterior teeth, whether multiple or individual, present a serious esthetic problem. Dental bleaching should be the first step taken in a treatment, since it is the most conservative one.

A preparation of sodium perborate and water in the "walking bleach" technique, for nonvital tooth bleaching, has been the most popular and recommended one, since the decomposition reaction of sodium perborate is slow and releases hydrogen peroxide in low concentration, giving a wider margin of safety in relation to other techniques.[1-4] Another bleaching agent that may be used in the "walking bleach" technique is 37% carbamide peroxide, which has been considered to be safe for the practice.

Once the bleaching process is complete, esthetic restorations may need to be replaced in order to achieve optimal shade matching. Thus, they are always filled with esthetic restorative materials such as resin composite or glass-ionomer cement. The prerequisites of these materials are to prevent microleakage and to improve the esthetic results.[5-7]

Some authors have reported detrimental effects on resin-tooth bonds as well as an increase of microleakage for the teeth restored after bleaching treatment.[6,8,9] This effect is attributed to the presence of residual peroxide or oxygen released from bleaching agents and structural changes on enamel and dentin composition that can affect the seal at the resin-tooth interface.[5,7,9] It is therefore important to know the real effect of the bleaching agents on the dental structure in order to avoid unsuccessful resin restorations.[10]

The purpose of this paper was to evaluate the microleakage of Class V adhesive resin restorations in teeth submitted to nonvital bleaching with two different bleaching agents.

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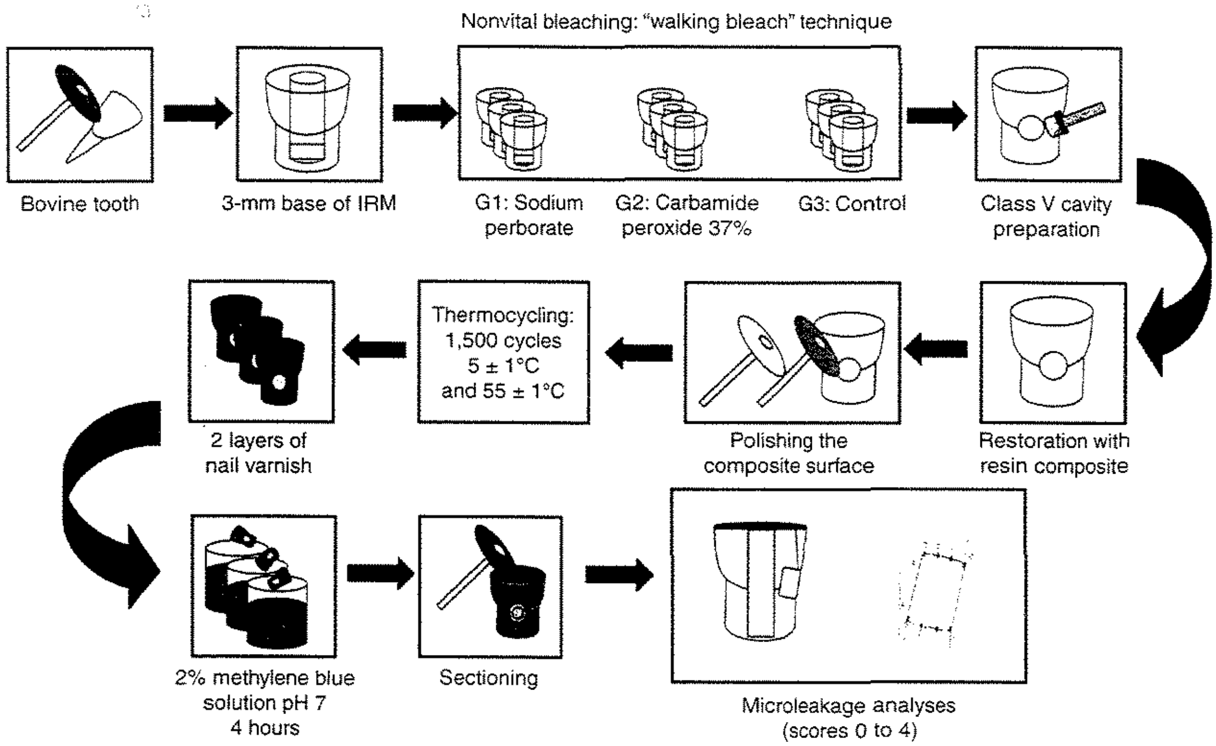

Fig 1 Scheme of the experiment.

METHOD AND MATERIALS

One hundred and twenty freshly extracted bovine teeth were stored in 2% formalin solution, cleaned, selected, and then stored in distilled water at room temperature to prevent dehydration. These teeth were horizontally sectioned approximately 7 mm incisally and apically to the cementoenamel junction using a double-faced diamond disc (reference no. 7020, KG Sorensen) to produce tooth segments (Fig 1). The contents of the pulp chamber and root canal were removed with a dental explorer, and the pulp chamber was enlarged with a No. 8 carbide bur using a low-speed handpiece (Kavo).

Three millimeters below the cementoenamel junction, a 3-mm thick base of intermediary restorative material (IRM) (Dentsply) was placed to prevent apical leakage of the bleaching material during the "walking bleach" technique. The teeth stored in a humidor (humidifier) were then randomly assigned to the following groups:

- Group 1/sodium perborate (SP): 40 bovine teeth bleached by a paste of sodium perborate (Proderma) and water (2 g of sodium perborate per 1 mL of water).
- Group 2/carbamide peroxide (CP): 40 bovine teeth bleached by 37% carbamide peroxide gel (Whiteness, FGM Produtos Odontológicos).
- Group 3/no bleaching (control): 40 nonbleached bovine teeth soaked in distilled water before restoration.

In groups SP and CP, the respective bleaching material was inserted in the pulp chamber, and a 2-mm thick surface seal was made with IRM. The bleaching agents were changed every 7 days for 2 weeks. The bleaching treatments were performed for 21 days. The teeth were stored in a humidor at 37°C during the bleaching period.

After bleaching, the incisal and apical regions were sealed with epoxy resin (Araldite Ciba Especialidades Química). A standardized cylindrical Class V cavity

TABLE 1 Statistical results

	Enamel ($P = 0.063$)			Dentin ($P < 0.05$)		
Groups	Median	n	Sum of ranks	Median	n	Sum of ranks
Sodium perborate	0	37	2104.5 a	1	37	2313.5 a
37% Carbamide peroxide	0	35	2200.0 a	1	35	2416.0 a
Control	0	37	1690.5 a	0	37	1265.5 b

The difference in letters next to the sum of ranks column expresses the significant statistical differences.

preparation (approximately 2.0 mm in diameter and 2.0 mm in depth) was done in the cementoenamel junction on the facial surface. A special diamond bur (reference no. 2294/KG Sorensen) in a high-speed handpiece (Kavo) with a constant water-spray coolant was used to prepare the cavities.

Before restoration, all cavities were rinsed with water in order to loosen all sediment left during preparation. Then, they were gently air-dried for 2 seconds to avoid dentin dehydration. The adhesive system Single Bond (3M Dental) was placed according to the manufacturer's recommendations. The cavity was etched for 15 seconds with a 35% phosphoric acid gel, and the etchant was rinsed for 10 seconds with water from an air-water syringe and briefly dried with compressed air for 2 seconds. Two consecutive coats of adhesive were applied using a saturated brush tip. After gently air drying for 5 seconds, the material was light cured for 10 seconds. The resin composite Z100 (3M Dental) was inserted in a bulk increment. The restored teeth were stored in a humidor at 37 ± 1°C for 24 hours, and the composite surface was polished with a graded series of Sof-Lex discs (3M Dental).

The teeth were placed in separate mesh bags and thermocycled in a thermocycling machine (MCT2, Instrumental Instrumentos de Precisão) for 1,500 cycles in water between 5 ± 1°C and 55 ± 1°C with a dwell time of 60 seconds in each bath. After thermocycling, the external surface of each tooth was coated with 2 layers of nail varnish, leaving a 1-mm wide margin around the restoration that was free of varnish. The teeth were placed in a 2% methylene blue solution (pH 7) for 4 hours at room temperature and rinsed under tap water. The teeth were sectioned longitudinally through the center of each restoration with a slow-speed double-faced diamond disc. The right half of each sectioned tooth was evaluated blindly and independently by 3 examiners with a stereomicroscope (Meiji 2000Techno, Meiji Techno) at ×35 magnification to determine the extent of microleakage at incisal and gingival margins. The following criteria were used to score dye penetration:

0 = No dye penetration
1 = Dye penetration to ⅓ of the incisal or gingival wall
2 = Dye penetration to ⅔ of the incisal or gingival wall
3 = Dye penetration to full length of the incisal or gingival wall
4 = Dye penetration including axial floor

Data were analyzed by Kruskal-Wallis and Mann-Whitney tests ($\alpha = 0.05$). These tests were chosen due to the nature of the qualitative random variable, which employs scores to evaluate the phenomenon under study (microleakage). The statistic calculations were performed by STATA software (Computing Resource Center Stata Reference Manual).

RESULTS

The microleakage median scores, the sum of ranks per bleaching treatment, and pair-wise comparisons for the restorative systems are presented in Table 1. The Kruskal-Wallis test showed no statistically significant differences in microleakage among treatment groups ($P = 0.063$, $\chi^2 = 5.507$; $\alpha < 0.05$) in enamel margins; however, statistically significant differences in microleakage were seen among the treatment groups ($P = 0.0001$, $\chi^2 = 25.009$; $\alpha < 0.05$) in dentin margins.

Comparisons of the sum of ranks on enamel margins showed no statistically significant differences among control and experimental groups. On dentin margins, comparisons of the sum of ranks in the bleached groups were statistically significantly different from the unbleached control group ($P < 0.05$). An increase in microleakage was found in both bleaching groups (SP and CP), showing the adverse potential of sodium perborate and 37% carbamide peroxide.

DISCUSSION

Bleaching procedures are often considered to be the first step in improving the appearance of discolored teeth.[5,11] Nonvital bleaching is often followed by placement of esthetic restorations. One of the prerequisites of such treatment is that the esthetic restoration prevents microleakage.[6] Several studies have shown that hydrogen peroxide released from bleaching agents adversely affects the bond strength of adhesive systems and resin composites to enamel.[6,8,9,12-14]

This work evaluated the influence nonvital bleaching agents might have on the microleakage of Class V adhesive restorations. The control group showed less microleakage in enamel and dentin margins than the bleaching groups (SP and CP). An increase in resin/dentin microleakage was found in groups SP and CP, showing the adverse potential of sodium perborate and 37% carbamide peroxide.

Some evaluations have demonstrated that teeth subjected to 10% carbamide peroxide have greater microleakage compared to nonbleached teeth.[5,8,9,12-16] A previous study proved that bleaching with 10% carbamide peroxide increased microleakage and interfered in the adhesion of resin restorations to dental structures.[17] Another investigation showed no measurable leakage along the enamel margins of Class V resin restorations, but the gingival dentin margins exhibited leakage, although the difference was not statistically significant.[7]

Barkhordar et al stated that bleaching had a minimum effect on the marginal seal of the resin restoration within the first 2 days and a significant effect after 4 to 7 days of bleaching, and concluded that the microleakage increased with the extent of bleaching time.[6]

Shear bond strength measurements and electron microscopy scanning examinations have shown changes in the bonds of resin composites after bleaching.[18-20] Tensile and shear tests of bleached teeth revealed a significant reduction in bond strength that was caused by an alteration in the adhesion mechanism and changes in resin quality at the enamel-resin interface.[6,10,13]

The loss of adhesive strength may be due to bleaching reactions.[8,12,14,20,21] Although these reactions are not totally known, the hypothesis is that as the oxidizing agent hydrogen peroxide diffuses through the dentin and enamel, the highly pigmented carbon ring compounds are opened and then converted into chains, which are lighter in color. As this process continues, the bleached tissue continually lightens with further decomposition of organic and inorganic matrix. During this process, water and oxygen are released.[21,22]

Some authors have suggested that the adverse effects of bleaching on resin-tooth bonds are caused by residual peroxides and oxygen that could inhibit the polymerization process of the adhesive systems.[14,20] In an electron microscopic scanning evaluation, nonbleached teeth presented numerous and clearly defined resin tags, in contrast with the teeth treated with 35% hydrogen peroxide for 30 minutes, where the resin tags were sparse, shorter, poorly defined, and structurally incomplete.[12]

However, a recent research study did not detect oxygen on the surface of bleached enamel, thus rejecting the hypothesis that residual oxygen leached from bleaching agents may interfere in the adhesive polymerization process.[23] Moreover, bleaching can induce changes in the ultra-morphology of enamel-resin bonded interfaces, changing the organic and inorganic component ratios, increasing the solubility of dental structures, and affecting dentin more than enamel.[6,23]

In this study, the microleakage of dentin margins in groups SP and CP was significantly higher than in the control group. However, such a difference did not occur among the enamel margins in groups SP, CP, and control ($P = 0.063$). The reason could be the difference in the composition of enamel and dentin. Dentin contains less mineral and more organic matrix and can easily be affected by hydrogen peroxide–based materials. These materials are strong oxidizing agents that may cause denaturation of proteins in the organic components, producing morphologic changes that could reduce the performance of resin bond restorations.

Another consideration is the presence of dentin tubules that may enhance the rate of penetration of the bleaching agents and residual oxygen diffusion from the pulp chamber through dentin. The consequence may be a higher concentration of residual oxygen in the more porous dentin margins than on enamel margins, thereby increasing microleakage.

It should be noted that the teeth used in this investigation were bovine, not human teeth, and the manner in which the bleaching agents were used was not the same as when bleaching is clinically performed.[9] Moreover, in the oral environment, the interaction with saliva may repair the tooth by mineral precipitation, and the action of enzymes (such as peroxidase and catalase) may leach out all residual peroxides and oxygen from the tooth, over an extended period of time, and improve the quality of resin-tooth bonds.[14,17]

It is necessary to know the time that has elapsed from the bleaching treatment to the restoration procedure to achieve an optimal seal, as well as to reduce the risk of microleakage in adhesive restorations.

CONCLUSION

1. Under the experimental circumstances used in this study, the Class V restorations in teeth submitted to nonvital bleaching with 37% carbamide peroxide gel or sodium perborate showed a significant increase in microleakage on dentin margins.
2. On enamel margins, the microleakage was not statistically different from the control group for both bleaching agents.
3. Even with regard to distance, the bleaching agents sodium perborate and 37% carbamide peroxide gel can interfere in the resin-tooth interface.

It is necessary to know the time that has elapsed from the bleaching treatment to the restoration procedure to achieve an optimal seal as well as to reduce the risk of microleakage in adhesive restorations.

ACKNOWLEDGMENT

The authors would like to acknowledge the support received from Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), grant # 99/00810-3.

REFERENCES

1. Rotstein I, Mor C, Friedman S. Prognosis of intracoronal bleaching with sodium perborate preparations in vitro: 1-year study. J Endod 1993;19:10–12.
2. Freccia WF, Peters DD, Lorton L, Benier WE. An in vitro comparison of nonvital bleaching techniques in the discolored tooth. J Endod 1982;8:70–77.
3. MacIsaac AM, Hoen CM. Intracoronal bleaching: Concerns and considerations. Scientific. J Can Dent Assoc 1994;60: 57–64.
4. Hara AT, Pimenta LAF. Nonvital tooth bleaching: A 2-year case report. Quintessence Int 1999;30:748–754.
5. Toko T, Hisamitsu H. Shear bond strength of resin composite to unbleached and bleached human dentine. Asian J Aesthet Dent 1993;1:33–36.
6. Barkhordar RA, Kempler D, Plesh O. Effect of nonvital tooth bleaching on microleakage of resin composite restorations. Quintessence Int 1997;28:341–344.
7. Crim GA. Prerestorative bleaching: Effect on microleakage of Class V cavities. Quintessence Int 1992;23:823–825.
8. Titley KC, Torneck CD, Smith DC, Adibfar A. Adhesion of resin composite to bleached and unbleached bovine enamel. J Dent Res 1988;67:1523–1528.
9. Torneck CD, Titley KC, Smith DC, Adibfar A. The influence of time of hydrogen peroxide exposure on the adhesion of resin composite to bleached bovine enamel. J Endod 1990; 16:123–128.
10. Garcia-Godoy F, Dodge WW, Donohue M, O'Quinn JA. composite resin bond strength after enamel bleaching. Oper Dent 1993;18:144–147.
11. Baratieri LN, Ritter AV, Monteiro S Jr, Andrada MAC, Vieira LCC. Nonvital tooth bleaching: Guidelines for the clinician. Quintessence Int 1995;26:597–608.
12. Titley KC, Torneck CD, Smith DC, Chernecky R, Adibfar A. Scanning electron microscopy observations on the penetration and structure of resin tags in bleached and unbleached bovine enamel. J Endod 1991;17:72–75.
13. Stokes NA, Hood JAA, Dhariwal D, Patel K. Effect of peroxide bleaches on resin-enamel bonds. Quintessence Int 1992;23:769–771.
14. Torneck CD, Titley KC, Smith DC, Adibfar A. Effect of water leaching on the adhesion of resin composite to bleached and unbleached bovine enamel. J Endod 1991;17: 156–160.
15. Demarco FF, Turbino ML, Jorge AG, Matson E. Influence of bleaching on dentin bond strength. Am J Dent 1998;11: 78–82.
16. Titley KC, Torneck CD, Ruse ND, Krmec D. Adhesion of a resin composite to bleached and unbleached human enamel. J Endod 1993;19:112–115.
17. Pimenta IC. Qualitative Evaluation of Microleakage in the Composite Resin Restorations After Bleaching Treatment with Carbamide Peroxide Gel [in Spanish]. Tese de mestrado da FOP- Unicamp - Curso de Clínica Odontológica, Piracicaba, 1998.
18. Seghi RR, Denry I. Effects of external bleaching on indentation and abrasion characteristics of human enamel in vitro. J Dent Res 1992;71:1340–1344.
19. Attin T, Kielbassa AM, Schwanenberg M, Hellwig E. Effect of fluoride treatment on remineralization of bleached enamel. J Oral Rehabil 1997;24:282–286.
20. Tames D, Grando LJ, Tames DR. Alterations on dental enamel submitted to 10% carbamide peroxide. Revista da APCD 1998;52:145–149.
21. Baratieri LN, Monteiro S Jr, Andrada MAC, Vieira LCC. Dental Bleaching [in Spanish]. São Paulo: Quintessence, 1993.
22. Goldstein GR, Kiremidjian-Schumacher L. Bleaching: Is it safe and effective? J Prosthet Dent 1993;69:325–328.
23. Perdigão J, Francci C, Swift EJ. Ultra-morphological study of the interaction of dental adhesives with carbamide peroxide-bleached enamel. Am J Dent 1998;11:291–301.

Quoted from : Quintessence International
5／2001，413-417

失活歯漂白後にコンポジットレジン修復を行った際の微少漏洩について
抜去歯での実験

In Vitro Microleakage of Composite Restorations After Nonvital Bleaching

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キーワード：漂白剤，変色歯，微少漏洩，失活歯，歯の漂白，Walking Bleach 法

はじめに

今日では，変色した前歯は，その数が多数かあるいは単独であるかにかかわらず，審美的に重要な問題であるとされている．歯の漂白法はもっとも歯質保存的な治療であり，審美回復のために，まず第一に選択することを考慮すべき処置法である．

過ホウ酸ナトリウムと水を使用するWalking Bleach 法は，過ホウ酸ナトリウムの分解反応がゆっくりと進行し，低濃度の過酸化水素を緩徐に放出するので，他の漂白法に比べるとより安全性の範囲が広く，一般的に推奨される方法である[1~4]．Walking Bleach 法に使われる他の薬剤として，臨床的に安全と考えられる37％の過酸化尿素ゲルがある．

漂白処置が終了すると，もっとも適切な色の調和を得るために再修復が必要になる症例もある．このような審美的修復には，コンポジットレジンやグラスアイオノマーセメントが用いられている．これらの材料に求められるのは，微少漏洩を避けること，審美性を改善することである[5~7]．漂白は，レジンと歯の接着にマイナスに作用し，漂白処置後に修復すると微少漏洩が増加すると報告されている[6,8,9]．この接着力が減少する理由は，漂白剤から放出された酸素が残留し，レジンの重合を阻害することや，エナメル質や象牙質の構造が変化し，レジン-歯質境界面の封鎖性に影響するためと考えられている[5,7,9]．レジン修復の失敗を避けるために，漂白剤の歯質構造への本当の影響を知ることは，非常に重要であると考えられる[10]．

この研究の目的は，それぞれ2種類の漂白剤を用いた失活漂白歯にV級コンポジットレジン修復を行った際の微少漏洩を検討し，接着性に対する評価を行うことである．

材料と方法

2％ホルマリン溶液に保管したウシの新鮮な抜去歯120本の汚れを取り除き，適切な歯を選択して，乾燥を避けるために室温中の蒸留水中に保管した．これらの歯は，*図1* に示すように，セメント-エナメル境で

訳）星野睦代／東光照夫／久光　久
（昭和大学歯学部保存修復学講座）

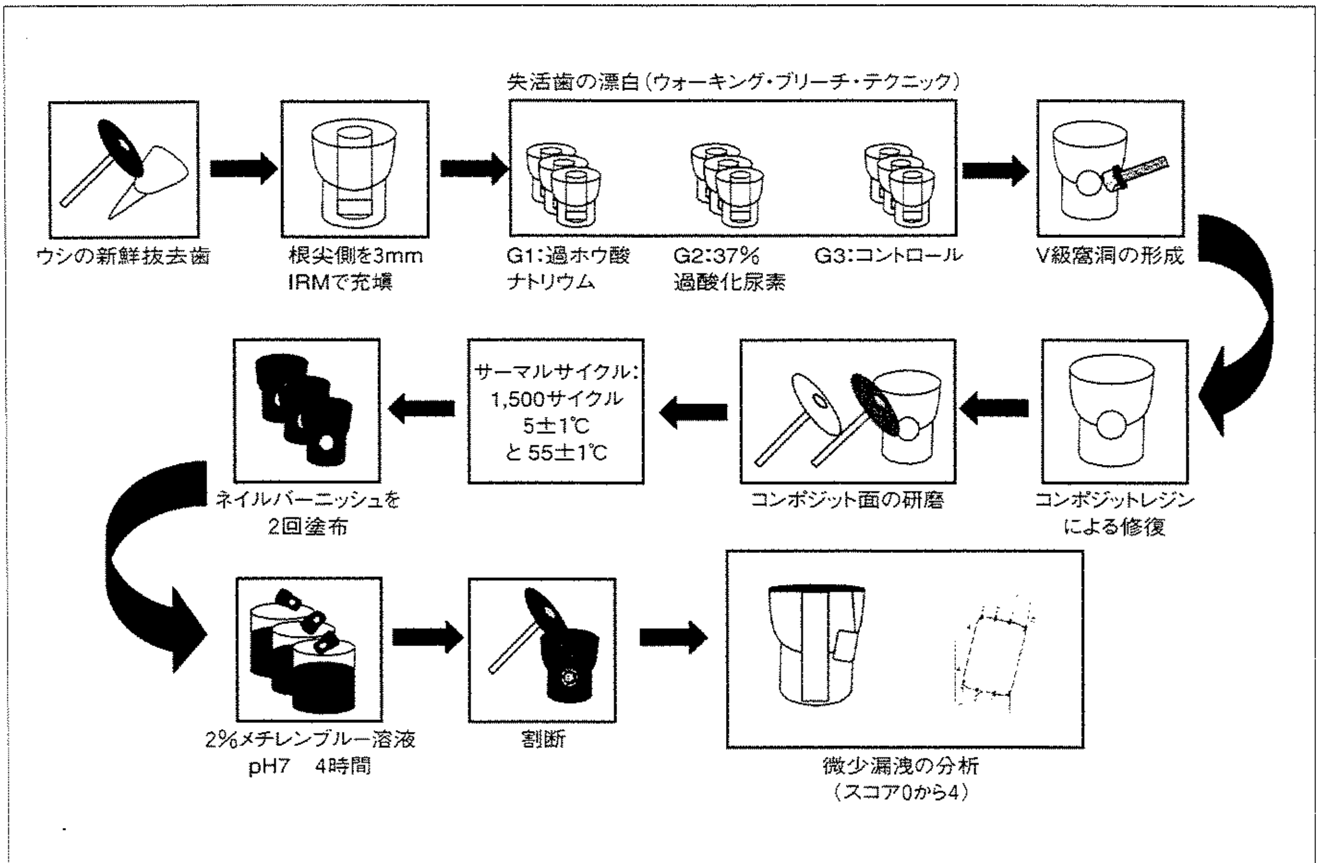

図1　実験の図解.

切端と根尖の間がおよそ7mmの高さになるように両面に刃のついたダイヤモンドディスク(#7020：KG Sorensen)で水平に分割し，試料片とした．髄腔の内容物と歯髄は探針で除去し，根管内は低速ハンドピース(KaVo)にNo 8のカーバイトバーを装着して拡大した．Walking Bleach法を行う期間中，漂白剤が根尖側から漏洩するのを避けるために，セメント-エナメル境の3mm下に3mmの厚さの修復材(IRM：Dentsply)を充塡した．恒湿箱(加湿器)のなかに保管した歯は，無作為に以下のようにグループ分けした．

・グループ1／過ホウ酸ナトリウム(SP)

過ホウ酸ナトリウム(Proderma)と水を混和したペースト(1 mlの水に2gの過ホウ酸ナトリウム)で漂白した40本の牛歯

・グループ2／過酸化尿素(CP)

37%の過酸化尿素ゲル(Whiteness：FGM Produtos Odontologicos製)で漂白した40本の牛歯

・グループ3／漂白処置なし(コントロール)

修復の前に蒸留水に浸した40本の牛歯

SPとCPのグループとも，それぞれの漂白剤を髄腔のなかに入れ，2mm厚のIRMで仮封した．漂白剤は7日間おきに交換し，漂白処置は21日間とした．漂白期間中，歯は37℃の恒湿箱に入れた．漂白終了後，切端側と根尖側はエポキシレジン(Araldite：Ciba Especialidades Quimica)で封鎖した．円筒形の規格化(直径約2mm，深さ約2mm)されたV級窩洞を，頬側面のセメント-エナメル境に形成した．特殊なダイヤモンドポイント(#2294：KG Sorensen)を，継続的にウォータースプレーで冷却する高速回転ハンドピース(KoVo)に装着し，窩洞を形成した．窩洞形成中に生じた汚れを取り除くために窩洞を水洗し，象牙質が脱水しない程度に2秒間程度慎重にエアーで乾燥させた．

接着には，シングルボンド接着システム(3M Dental製)を指示書どおりに使用した．修復手順は，窩洞を

35%リン酸で15秒間エッチングしてシリンジで水洗し，その後にエアーで軽く乾燥させた．ボンディング材は，ブラシで２回繰り返して塗布した．その後，弱圧でエアーブローを５秒間行い，さらに10秒間ボンディング材に光照射した．光重合コンポジットレジン Z100(3M Dental 製)を窩洞に一塊で填塞した．レジン修復後の歯は，37±１℃の恒湿箱に24時間入れ，その後コンポジットレジン表面を Sof-Lex ディスク(3M Dental 製)で順次研磨した．

試料の歯は１本ずつメッシュバックに入れ，サーマルサイクル装置(MCT2：Instrumental Instrumentos de Precisao)で冷却加熱を繰り返した．サーマルサイクル槽の各々の温度は５±１℃と55±１℃で，これを各60秒間ずつ1,500サイクル行った．サーマルサイクリング後，歯の表面にネイルバーニッシュを２回塗布してシールしたが，修復部位から１mm 離れたところにはネイルバーニッシュは塗布しなかった．これらの歯は，２%メチレンブルー溶液(pH７)に室温で４時間浸漬し，色素を浸透させて水洗した．色素浸透後の試料は，低速回転の両面ダイヤモンドディスクを用いて修復部位の中央で割断した．

漏洩の程度を評価するために，３名の評価者が個別に割断した歯の半分を実体顕微鏡(Meiji 2000Techno：Meiji Techno)倍率35を使って，歯頂側と歯肉側における漏洩の程度を評価した．色素浸透の評価基準は，以下に示す判定基準とした．

０＝染色液の浸透なし

１＝染色液の浸透が歯頂側，歯肉側壁の１/３に及ぶ

２＝染色液の浸透が歯頂側，歯肉側壁の２/３に及ぶ

３＝染色液の浸透が歯頂側，歯肉側壁のすべてに及ぶ

４＝染色液の浸透が軸側壁の窩底にまで及ぶ

得られたデータは，Kruskal-Wallis と Mann Whitney tests(d＝0.05)で統計学的に検定した．これらの検定法は，質的に無作為で可変的であるという理由で選択され，色素漏洩を評価するスコアに対して用いられた．実際の統計学的計算は，STATA software(Computing Resource Center Stata Reference Manual)で行った．

表 1　統計学的結果．

グループ	エナメル質(P＝0.063)			象牙質(P<0.05)		
	中央値	n	ランクの和	中央値	n	ランクの和
過ホウ酸ナトリウム	0	37	2104.5a	1	37	2313.5a
37%過酸化尿素	0	35	2200.0a	1	35	2416.0a
コントロール	0	37	1690.5a	0	37	1265.5b

ランクの和の縦の列の数字の隣の文字の違いは，統計学的有意差があることを示している．

結果

表 1 に，窩縁の状態(エナメル窩縁あるいは象牙質窩縁)，漏洩のスコアの中央値，試料数，それぞれの漂白処理の順位の和(ランクの合計)を示す．Kruskal-Wallis test は，グループ間のエナメル質窩縁で漏洩に統計学的有意差がないこと($P=0.063$，$\chi^2=5.507$；$\alpha<0.05$)を示している．しかし，象牙質窩縁では有意差($P=0.0001$，$\chi^2=25.009$；$\alpha<0.05$)がみられた．エナメル質窩縁における順位の和の比較では，コントロールと実験群の間に有意差はなかった．象牙質窩縁で漂白処置群の順位の和を比較すると，コントロール群と有意差があった($P<0.05$)．微少漏洩の増大が，過ホウ酸ナトリウム(SP)と37%過酸化尿素(CP)の漂白を行った群にみられ，これは SP と CP による漂白が，コンポジットレジンの接着性を阻害することを示していた．

考察

歯の漂白法は，しばしば変色歯の審美性を改善する第一段階の方法であると考えられている[5,11]．通常，失活歯の漂白を行ったあとには，引き続いて審美修復が行われることが多い．このような治療の必要条件の１つは，審美修復が微少漏洩を起こさないようにするということである[6]．

漂白剤から放出された過酸化水素が，エナメル質に対するコンポジットレジンの接着システムの接着を阻害する作用を示すことがいくつかの研究で述べられている[6,8,9,12~14]．この研究は，Ｖ級窩洞に接着性修復を

行った場合に，失活歯漂白剤が漏洩を引き起こす可能性を検討したものである．その結果，コントロールグループのほうが，象牙質辺縁で漂白グループ(過ホウ酸ナトリウム：SP と37%過酸化尿素：CP)よりも漏洩が少ないことが明らかになった．コンポジットレジンと象牙質との間の漏洩の増加は，SP と CP が接着性を阻害する可能性を示唆している．

10%過酸化尿素で漂白した歯とコントロールの歯を比較した場合，漂白した歯のほうが漏洩は大きかったとする他の報告もある[5,8,9,12~16]．10%過酸化尿素で漂白すると辺縁漏洩が増加するが，これは歯の構造へのレジンの接着が妨げられているからであるという報告もある[17]．また，V級レジン修復のエナメル質辺縁に沿って測定できる漏洩は認めらなかったが，他の報告には歯肉側窩縁の象牙質側で有意差はないが漏洩はあるとするものがある[7]．Barkhordar らは，2日間の漂白はレジン修復の辺縁封鎖に与える影響は少なく，漂白が4～7日間に及ぶと漏洩が増加すると述べている[6]．

歯質とコンポジットレジンの接着性を剪断接着強さで評価し，さらに接着面を走査電子顕微鏡で観察すると，漂白された歯とレジンとの接着性は変化することが観察された[18~20]．レジンと歯質の引っ張り接着強さと剪断接着強さの減少は，接着機構の変化とエナメル-レジン境界のレジンの質が変化することに起因している[6,10,13]．接着強さの喪失は，漂白反応によるものであろう[8,12,14,20,21]．しかし，漂白反応の詳細は完全には解明されておらず，酸化因子である過酸化水素が象牙質とエナメル質に拡散して，微細な個々の炭素環化合物を開環して炭素直鎖に変化させ，そのことで色が薄い色にみえるようになるという説がある．

この反応が進行すると，漂白された組織はさらなる有機物や無機物の構造の分解を伴いながら，継続的に明度を増していく．この反応が進行する間，水と酸素が放出される[21,22]．レジンと歯の接着阻害は，残留した過酸化物と酸素が接着システムの重合反応を阻害することによって引き起こされていると示唆する研究者たちがいる[14,20]．電子顕微鏡による研究では，漂白されていない歯は35%過酸化水素で30分間処理されたものに比べて明らかに多くの明瞭なレジンタグを見出すことができる．漂白された歯では，レジンタグはまばらで短くはっきりしない形状であり，構造的に不完全な形で観察される[12]．しかし，最近の研究では漂白されたエナメル質表面には酸素は検出されず，漂白剤から発生した酸素がレジンの重合過程を阻害するという説は否定される[23]．さらに，漂白はエナメルとレジン境界の有機・無機質の構成比率を変化させ，歯の構造の溶解性を増加させ，とくにエナメル質よりも象牙質において超微細構造の変化を誘発している[6,23]．

本研究では，SP 群と CP 群の象牙質窩縁での微少漏洩が，エナメル質窩縁より大きいことを示した．しかし，SP 群と CP 群，コントロール群のエナメル質窩縁ではこのような差は生じなかった(P=0.0063)．理由は，エナメル質と象牙質の組成の差によるものと考えられる．象牙質は，エナメル質よりも無機成分が少なく，より多くの有機成分を含み，過酸化物により容易に影響を受けるからである．過酸化物は有機物中のタンパク質を変性させ，レジンと接着性修復物の有用性を減少させる形態的変化を引き起こすとされている．そのほかの考察としては，漂白剤の浸透率を増加させ，残留酸素を髄腔から象牙質を通過させてしまう象牙細管の存在がある．象牙細管の存在により，エナメル窩縁に比べて多孔性の象牙質窩縁に高濃度の残留酸素が存在し，漏洩が増加する．

本研究では，ヒトの歯ではなくウシの歯を使い，漂白の術式は臨床で行われているのとは異なっていたことにも注意を向けるべきである[9]．さらに，口腔内環境では，唾液内成分が沈着することによる歯の表面の修復という歯質と唾液の相互作用があり，ペルオキシダーゼやカタラーゼなどの酵素の作用により歯の残留過酸化物や酸素が時間の経過とともに変化し，レジンと歯の接着の質を変えていることにも注目すべきである[14,17]．接着修復の辺縁漏洩の危険性を減少させるのと同様に，もっともよい封鎖性を得るためには，漂白から修復処置までの時間経過を知ることが必要である．

結論

①本研究で用いた実験の環境下では，37%過酸化尿素や過ホウ酸ナトリウムで失活歯漂白した歯にV級修復を施した場合，象牙質辺縁で統計学的に有意差のある辺縁漏洩が認められた．

②エナメル質窩縁では，コントロール群と2種の漂白剤の群の間に，有意差はなかった．

③薬剤からの距離を考慮したとしても，過ホウ酸ナトリウムや37%過酸化尿素ゲルは，レジンと歯の接着界面に影響を与えていることが明らかになった．

接着修復の辺縁漏洩の危険性を減少させるのと同様に，もっともよい封鎖性を得るために，漂白から修復過程までの時間を知ることが必要であると考えられた．

謝辞

筆者らは，Fundação de Amparo à Pesquisado Estado de São Paulo(FAPESP)からの助成金(#99／00810-3)等の支援に感謝の意を表します．

参考文献

1. Rotstein I. Mor C. Friedman S: Prognosis of intracoronal bleaching with sodium perborate preparations *in vistro* : 1-year study. J Endod, 19 : 10-12, 1993.
2. Freccia WF. Peters DD. Lorton L. Benier WE: An *in vitro* comparison of nonvital bleaching techniques in the discolored tooth. J Endod, 8 : 70-77, 1982.
3. MacIsaac AM. Hoen CM: Intracoronal bleaching: Concerns and considerations. Scientific. J Can Dent Assoc, 60 : 57-64, 1994.
4. Hara AT. Pimenta LAF: Nonvital tooth bleaching: A 2-year case report. Quintessence Int, 30 : 748-754, 1999.
5. Toko T. Hisamitsu H: Shear bond strength of resin composite to unbleached and bleached human dentine. Asian J Aesthet Dent, 1 : 33-36, 1993.
6. Barkhordar RA. Kempler D. Plesh O: Effect of nonvital tooth bleaching on microleakage of resin composite restorations. Quintessence Int, 28 : 341-344, 1997.
7. Crim GA: Prerestorative bleaching: Effect on microleakage of Class V cavities. Quintessence Int, 23 : 823-825, 1992.
8. Titley KC. Torneck CD. Smith DC. Adibfar A: Adhesion of resin composite to bleached and unbleached bovine enamel. J Dent Res, 67 : 1523-1528, 1988.
9. Torneck CD. Titley KC. Smith DC. Adibfar A: The influence of time of hydrogen peroxide exposure on the adhesion of resin composite to bleached bovine enamel. J Endod, 16 : 123-128, 1990.
10. Garcia-Godoy F. Dodge WW. Donohue M. O'Quinn JA: Composite resin bond strength after ename bleaching. Oper Dnet, 18 : 144-147, 1993
11. Baratieri LN. Ritter AV. Monteiro S Jr. Andrada MAC. Vieira LCC: Nonvital tooth bleaching: Guidelines for the clinician. Quintessence Int, 26 : 597-608, 1995.
12. Titley KC. Torneck CD. Smith DC. Chernecky R. Adibfar A: Scanning electron microscopy observations on the penetration and structure of resin tags in bleached and unbleached bovine enamel. J Endod, 17 : 72-75, 1991.
13. Stokes NA. Hood JAA. Dhariwal D. Patel K: Effect peroxide bleaches on resin-enamel bonds. Quintessence Int, 23 : 769-771, 1992.
14. Torneck CD. Titley KC. Smith DC. Adibfar A: Effect of water leaching on the adhesion of resin composite to bleached and unbleached bovine enamel. J Endod, 17 : 156-160, 1991.
15. Demarco FF. Turbino ML. Jorge AG. Matson E: Influence of bleaching on dentin bond strength. Am J Dent, 11 : 78-82, 1998.
16. Titley KC. Torneck CD. Ruse ND. Krmec D: Adhesion of a resin composite to bleached and unbleached human enamel. J Endod, 19 : 112-115, 1993.
17. Pimenta IC: Qualitative evaluation of microleakage in the composite resin restorations after bleaching treatment with carbamide peroxide gel[in Spanish]. Tese de mestrado da FOP- Unicamp-Curso de Clínica Odontológica. Piracicaba, 1998.
18. Seghi RR. Denry I: Effects of external bleaching on indentation and abrasion characteristics of human enamel *in vitro*. J Dent Res, 71 : 1340-1344, 1992.
19. Attin T. Kielbassa AM. Schwanenberg M. Hellwig E: Effect of fluoride treatment on remineralization of bleached enamel. J Oral Rehabil, 24 : 282-286, 1997.
20. Tames D. Grando LJ. Tames DR: Alterations on dental enamel submitted to 10% carbamide peroxide. Revista da APCD, 52 : 145-149, 1998.
21. Baratieri LN. Monteiro S Jr. Andrada MAC. Vieira LCC: Dental bleaching[in Spanish]. São Paulo. Quintessence, 1993.
22. Goldstein GR. Kiremidjian-Schumacher L: Bleaching: Is it safe and effective? J Prosthet Dent, 69 : 325-328, 1993.
23. Perdigão J. Francci C. Swift EJ: Ultra-morphological study of the interaction of dental adhesives with carbamide peroxide-bleached enamel. Am J Dent, 11 : 291-301, 1998.