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Resumen

Con la realización de este estudio se pretende agrupar la información relacionada con las técnicas de protección del complejo dentino pulpar cuyo sellado dentinario inmediato y el resin coating. Del mismo modo el trabajo proporciona información sobre la histología dental y analiza ventajas e inconvenientes de las técnicas empleadas. El sellado dentinario asume gran importancia en tratamientos de restauraciones fijas y se describe como la aplicación de un agente resinoso de unión en condiciones de exposición dentinaria póstumamente a una preparación.

Objetivos: este estudio de revisión bibliográfica tiene como objetivo describir la importancia de la preservación del complejo dentino pulpar proporcionando los protocolos de sellado dentinario inmediato y resin coating y comentando las indicaciones.

Materiales y métodos: Se utilizaron las bases de datos de la Biblioteca CRAI de Universidad Europea de Madrid y los más importantes buscadores científicos electrónicos: Scielo, Medline Complete, PubMed, Scopus, Web of Science. **Palabras claves:** *sellado dentinario; sellado dentinario inmediato; sellado dentinario demorado; sensibilidad postoperatoria; restauraciones indirectas; protocolos de imprimación; dentina; adhesivo.*

Resultados: Apoyándose en la información recogida en la búsqueda bibliográfica se puede afirmar que el sellado dentinario inmediato fomenta la longevidad de la restauración y la fuerza adhesiva, si se emplea antes de la impresión definitiva. El adhesivo más indicado según la bibliografía es un adhesivo con relleno de grabado acido total de dos pasos, el Optibond FL,

que impermeabiliza la dentina, protege el complejo dentino pulpar y disminuye la sensibilidad incrementando la adhesión.

Conclusiones: La introducción del protocolo de sellado dentinario inmediato ha mejorado la protección del órgano dental alejando la hipersensibilidad postoperatoria y mejorando la unión, además ha reducido el número de endodoncias causadas por la sensibilidad permanente postoperatoria.

Abstract

The aim of this study is to bring together information related to the techniques used to protect the dentin-pulp complex, namely immediate dentin sealing and resin coating. Likewise, the work provides information on dental histology and analyzes the advantages and disadvantages of the techniques used. Dentin sealing assumes great importance in the treatment of fixed restorations and it is described as the application of a resin bonding agent under conditions of dentin exposure posthumously to a preparation.

Objectives: This literature review study aims to describe the importance of preserving the dentin-pulp complex by providing immediate dentin sealing and resin coating protocols and commenting on the indications.

Materials and methods: The databases of the CRAI Library of the Universidad Europea de Madrid and the most important electronic scientific search engines were used: Scielo, Medline Complete, PubMed, Scopus, Web of Science. **Keywords**: *dentin sealing; immediate dentin sealing; delayed dentin sealing; postoperative sensitivity; indirect restorations; priming protocols; dentin; adhesive*.

Results: Based on the information gathered in the literature search, it can be stated that immediate dentin sealing promotes the longevity of the restoration and adhesive strength, if used before the final impression. The most indicated adhesive according to the literature is a two-step total acid-etch filled adhesive, Optibond FL, which seals the dentine, protects the dentine-pulp complex and decreases sensitivity by increasing adhesion.

Conclusions: The introduction of the immediate dentine sealing protocol has improved the protection of the tooth organ by preventing postoperative hypersensitivity and improving bonding and has reduced the number of root canals caused by permanent postoperative sensitivity.

Índice

1. Introducción

La odontología, en particular la odontología adhesiva, ha evolucionado mucho en las ultimas décadas y, hoy en día, está en continuo cambio buscando tecnologías, biomateriales, técnicas y protocolos que deben respetar la ordenada elegancia del microscópico mundo del diente. Se fomenta el objetivo de lograr una mayor preservación de los tejidos remanentes sanos para beneficiar de la adhesión dental y su permanencia en el tiempo (1,2).

La odontología conservadora en general, gracias al desarrollo de diferentes biomateriales, se ha inclinado hacia la técnica adhesiva, siendo tema de discusión e inspiración para muchos especialistas en distintas ramas. Las primeras restauraciones adheridas eran amalgamas y orificaciones, las cuales ofrecían características requeridas como, por ejemplo, una óptima adaptación física; se aporta de esta manera, una mayor resistencia marginal a la filtración y calidad eficaz contra la aparición de caries secundarias. Por otro lado, contrariamente con lo anteriormente dicho, estos materiales no cumplen todos los requisitos estéticos exigidos en la actualidad. De hecho, composites y cerámicas superan en distintas situaciones clínicas las anteriormente mencionadas, lo que empujó a la odontología a introducir en los protocolos restauradores, tanto directos como indirectos, el uso de adhesivos (1–4).

En la odontología moderna los adhesivos cumplen un papel fundamental y de suma importancia en el campo de la estética y de la conservadora, así como en tratamientos protésicos y endodónticos. La innovación de los últimos años pide a los materiales una mejora de algunas características, sin olvidar el funcionamiento de estos y de los componentes que lo constituyen.

De igual forma, se intenta buscar cómo incrementar el resultado, optimizando el tiempo clínico y simplificando la técnica (2).

En las primeras etapas de los años noventa, se propuso introducir nuevas técnicas para preservar de forma óptima la integridad del tejido dentario remanente. Como métodos de protección fueron utilizados el sellado dentinario inmediato (SDI) y el resin coating, describiendo ventajas, indicaciones y dos protocolos distintos con un objetivo común (1,5,6).

Entre los artículos, De Munck y cols. En 2005 afirman que la principal causa de fracaso de las restauraciones adhesivas es la microfiltración marginal producida por la degradación de la interfase adhesiva (7). La pérdida de integridad marginal de las restauraciones es el principal factor que induce a problemáticas cuyas apariciones de caries secundarias, decoloraciónes marginales, pérdida de retención, fracturas de los materiales y, sobretodo, sensibilidad postoperatoria (8–13). Efectivamente, según la literatura, en la técnica de preparación de un elemento dentario puede ser común la exposición de la dentina, lo que, en la mayoría de los casos, conlleva a la aparición de sensibilidad postoperatoria (9,10,12,13). Esta es una de las motivaciones fundamentales por lo cual es importante cuidar los tejidos dentales durante el periodo de provisionalización para mejorar el éxito de las restauraciones adhesivas (5).

Hoy en día se intenta crear una verdadera interfase, constituida por la unión del primer, parte hidrofilica del adhesivo, con el tejido dentario y el bonding, componente hidrofóbico, capaz de soportar las fuerzas entre el tejido dentario y la restauración, con la resina. Se genera de esta manera, una unión química con la dentina gracias al primer (1,6).

Con los avances de la odontología adhesiva se fueron por lo tanto modificando algunos conceptos que se empleaban para la preparación de los dientes en prótesis fija, como la retención por fricción y la retención mecánica, que debido a la necesidad de un diseño especifico, podían incluso ser dañinos y debilitantes para las piezas tratadas a causa de una sobre-preparación (5,6,14).

Se comprobó que es de fundamental importancia para llevar a cabo una buena interfase adhesiva, preservar y conservar la mayor cantidad posible de esmalte y dentina sanos. Debido a eso, las preparaciones dentarias han evolucionado adquiriendo una mejora en la forma y en los limites, alejándose así de aquellas conformaciones retentivas destinadas a restauraciones metálicas (1,6,14).

El hecho de tener una buena interfase, permite a la restauración protésica adherirse de forma eficaz y mas duradera a la superficie del diente, multiplicando la resistencia a fuerzas axiales, traccionales y compresivas que se producen durante la masticación (15,16).

Es esencial recalcar que la dentina vital expuesta inminentemente después de la preparación es susceptible a una penetración bacteriana y microfiltración en el período de los provisionales. La capacidad de las bacterias de invadir los tejidos dentarios, se traduce en la penetración de fluido séptico a través de los túbulos dentinarios, produciendo dolor postoperatorio y una potencial irritación pulpar (4,5).

1.1. Esmalte

Es la capa mas superficial y escudo fundamental del diente, revela en su interior una complicada arquitectura, a diferencia de otros tejidos no tiene células ni paquete vasculo-nervioso, es el tejido más radiopaco del organismo. Su estructura está compuesta homogéneamente por prismas de esmalte y su composición es el 90-96% inorgánica de contenido mineral, por el 2-4% de agua y, el mínimo remanente, está constituido por su materia orgánica. Esta última, se encuentra intercalada entre los cristales y está compuesta, en casi su totalidad (90%), por proteínas de naturaleza amelogeninas (4).

Su componente fundamental es el calcio que se encuentra en forma de precipitación de fosfato, sobretodo hidroxiapatita. Están presentes otros minerales como potasio, magnesio, hierro y flúor. Este último, tiene la capacidad de sustituir a los grupos hidroxilos, transformando la hidroxiapatita en fluorapatita. Esta transformación hace que el esmalte sea menos soluble en medios ácidos, respecto a su condición fisiológica. Efectivamente, el esmalte esta también carente de células y paquete vasculo-nervioso, así como de capacidad cicatricial y regenerativa. Sin embargo, se destaca, por última y de igual importancia la capacidad de remineralización, cualidad fundamental de esta estructura (4,14,17).

Los cristales que forman la parte mineral del esmalte (hidroxiapatita) tienen una naturaleza iónica confiriendo la capacidad de producir uniones de alta energía superficial que, junto al bajo porcentaje de agua en el esmalte, apoyan a las fuerzas adhesivas a este sustrato (17).

La adhesión al esmalte es una unión micromecánica que pide sacrificar irreversiblemente porción de tejido inorgánico, conformando microporos que, como resultado, aumentan la retención (14).

Por esta razón, a la hora de grabar la superficie con ácido ortoforsforico, se forman sales solubles de fosfato cálcico que una vez lavados, crean un área de alta energía superficial favoreciendo la adhesión al diente. El protocolo de grabado del esmalte fue propuesto por primera vez por M. Buoncore en el 1955 (14,15,17).

El grabado del esmalte separa los minerales que luego serán remplazados por monómeros que una vez polimerizados, formarán una unión mecánica estable (14). La adhesión al esmalte es sólida y fiable, con bajos valores de degradación de la interfase diente – resina, lo que aporta una buena resistencia adhesiva (17).

1.2. Dentina

La dentina es otra parte del tejido dental, menos mineralizada en comparación con el esmalte. Se compone por un 22-30% de materia orgánica, cantidad evidentemente mayor con respecto al tejido adamantino. El 10-20% está constituido por agua y fibras de colágeno, formadas en un 90% por colágeno tipo I. Estas fibras se entrelazan creando una malla donde los cristales de hidroxiapatita, presentes en cantidades muy elevadas, se apoyan, conformando el 50-68% de la materia inorgánica dentinaria (4,16,18).

La dentina, a diferencia del esmalte, por su composición, es menos resistente pero más elástica, por lo que desarrolla el papel fundamental de amortiguador del esmalte y mensajero de la pulpa. Enfocando la atención en estos dos tejidos dentales, parece evidente que nacen para trabajar juntos (3).

En otras palabras, el esmalte sufre mucho las fuerzas por ser muy resistente y se apoya en la dentina que las dispersa para proteger el esmalte de posibles fracturas. Por otro lado la dentina está en íntimo contacto con la pulpa por compartir el origen embrionario y constituyendo un conjunto funcional y estructural, definido complejo dentino-pulpar (3,4).

Igual que el esmalte, la dentina también se organiza de forma bastante complicada, conformando una vía de comunicación mediante estructuras cilíndricas (túbulos), que se extienden en diferentes direcciones, desde el interior hacia el esmalte, la pulpa y, a nivel radicular, hacia el cemento. Desde el punto de vista histológico en la porción dentinaria más profunda, se disponen las prolongaciones nerviosas llamadas fibrillas de Tomes, y el líquido dentinario, o fluido odontoblástico, que son encargados de conducir estímulos. De igual manera la cantidad y el número de túbulos van aumentando según nos acercamos a la pulpa, por lo contrario, a medida que nos acercamos a la periferia, encontramos más dentina aún más mineralizada. La cantidad y la calidad de la dentina depende de muchos factores, sobre todo de la edad y las disfunciones cráneo maxilares, que son las causas del cambio en la organización microscópica de la dentina (3,4,18,19).

Con respecto a la edad, este cambio proporciona sustratos con características diferentes, incidiendo sobre su permeabilidad (3,4,18,19).
El desarrollo de adhesivos esmalte-dentinarios está estrechamente relacionado con la introducción en el mercado de materiales de restauración resinosos, inicialmente propuestos como materiales de restauración estéticos, que hoy se utilizan de distintas formas dentro de muchas ramas de la odontología (3,4).

Se propuso aplicar el concepto de grabado ácido en la odontología para hacer que el sustrato fuese más sensible a la adhesión, aprovechando la organización del esmalte. El ácido ortofosfórico, en concentraciones de 32-37% y aplicado por un periodo de 15-60 s, produce un efecto positivo y proporciona un sustrato favorable a la adhesión. Un error o distracción por parte del operador puede conseguir un tipo de grabado erróneo o de peor calidad (3,4,17).

Podemos afirmar que la dentina profunda tiene mayor permeabilidad, por definición histológica, respecto a la dentina superficial, aumentando tanto el numero como el tamaño de los mismos túbulos dentinarios (4,12,19).

Inicialmente, la técnica adhesiva y las resinas compuestas solo se usaban para reparar dientes careados o fracturados, hoy en día los adhesivos se pueden usar en muchas aplicaciones, entre ellas:

- La reconstrucción de erosiones o abrasiones cervicales.
- La cementación adhesiva de inlays, onlays carillas y coronas.

- La retención de ferulizaciones metálicas.
- La aplicación de brackets de ortodoncia.
- El tratamiento de la hipersensibilidad dentinaria.
- La reparación de fracturas en el contexto de prótesis cerámicas fijas (3,12,19,20).

1.3. Aislamiento

Cuando se realiza una técnica de SD o de preparación dental es fundamental crear una cavidad lisa, limpia y sellada con el sistema adhesivo más apropiado. La técnica de aislamiento absoluto, técnica correcta en la mayoría de los procedimientos dentarios, ayuda a alcanzar los objetivos prefijados acorde a los límites de la preparación, la cual deberá ser estrictamente supragingival, siendo de difícil manejo los limites subgingivales (21).

1.4. Introducción a la Adhesión

Cuando se prepara con instrumentos rotatorios un elemento dentario con una finalidad protésica o restauradora, se crea una capa de barrillo dentinario en la superficie del elemento. El concepto de barrillo dentinario, introducido por Boyde y Stewart en el año 1963, se describe como el resultado de la preparación del elemento dentario, constituido por materia orgánica, materia inorgánica y restos dentinarios (4,12,22)

Esta capa no es un medio favorable como puede ser la dentina limpia y recién tallada y para lograr una buena y resistente adhesión, hay que eliminarla (3,4).

Entre la amplia disponibilidad del mercado y el continuo cambio generacional, hoy en día, somos capaces de reunir los adhesivos en una combinación de los tres pasos básicos de adhesión dentinaria:

1. Acondicionamiento.
2. Imprimación Resina Hidrófila o Primer se utiliza por su composición en sustratos como dentina acondicionada, creando los tags.
3. Bondig, resina hidrófuga, es la verdadera interfase entre el diente y la restauración conformando una delgada capa limpia.

Basados en estos tres pasos, los adhesivos comercializados se pueden encontrar con uno de estos pasos combinados o también en un único paso (4).

Como hemos mencionado anteriormente, los adhesivos pueden ser diferentes y los clasificamos de forma simple dividiéndolos en dos grupos: Grabado total y de Autograbado. Siguiendo los sistemas de autograbado destacamos dos subgrupos, Autograbado de dos pasos y de un paso o simplificado comúnmente conocido como “all in one” (4,23).

Cada adhesivo tiene unas características e indicaciones del fabricante para su uso de la mejor forma, dependiendo del tipo y calidad de sustrato, se elegiría un adhesivo respecto a otro más simplificado, sin olvidar ninguno de los pasos anteriormente citados. Igual que para el esmalte, el ácido ortofosforico es el material de elección para el acondicionamiento dentinario, eliminando por completo la capa de detritus resultado de la previa preparación del elemento dentario, dejando las fibras de colágeno descalcificadas, que quedarán expuestas hasta la aplicación de los agentes resinosos adhesivos (hidrófilas e hidrófugas) (1,3,4,6).

Es fundamental por lo tanto conocer la composición del adhesivo y el protocolo para la correcta aplicación del mismo con el objetivo de mejorar la resistencia adhesiva, aprovechando así el sustrato a disposición que se presta para otorgar los requisitos y respetar el importantísimo complejo dentino-pulpar.
En la literatura se destaca el papel fundamental de los tejidos dentales. La resistencia interior que desarrollan ductilidad y flexibilidad permite amortiguar las fuerzas, pero hasta un cierto punto. Cuanto más resiliente sea una estructura mejor será (3).

La dentina no tiene como el esmalte una adhesión fácil de controlar y segura al 100%, siendo muchos los factores a tener en cuenta. Eso puede llevar a una degradación prematura de la interfase adhesiva causado por un error y pudiendo cursar en el fracaso y peor pronóstico de la restauración adhesiva. De hecho, hoy en día se utiliza el procedimiento de sellado dentinario inmediato dibujado por P. Magne (24).

Los estudios transmitidos por Buoncore y cols. nos hace partícipes del conocimiento de la adhesión al esmalte, considerándola un medio previsiblemente seguro y de fiable durabilidad (17). Asimismo, en los estudios de E. Padros y cols. se destaca que la dentina por otro lado es un sustrato que requiere una cierta complejidad de manejo y una elección pensada del material adhesivo (4,22).

1.5. La capa híbrida

En el año 1991 fue introducido por Nakabayashi el concepto de “capa híbrida” entidad principal en relación con la adhesión a la dentina. En consonancia con esta noción, la perfusión intratubular del monómero resinoso adhesivo, entrando en contacto con las fibras colágenas, sella herméticamente la dentina formando una capa lisa y limpia, aumentando la superficie de contacto y permitiendo así una adhesión eficaz (25).

La meta para garantizar la durabilidad de la restauración adhesiva es precisamente la capacidad de la capa hibrida de mantenerse y resistir en el tiempo, además P. Magne en su articulo confirma que el sistema adhesivo a tres pasos es un óptimo medio para lograr una fuerza adhesiva adecuada, sin contaminación, debida a los cementos provisionales. Es indicado entonces, aplicar un adhesivo antes le las impresiones finales para lograr resultados de adhesión mejoradas (6,25,26).

1.6. Definición de SDI

El sellado inmediato de la dentina consiste en la aplicación de un sistema adhesivo de forma aislada o en asociación con una resina de baja viscosidad sobre la dentina recién preparada. Debe ser realizada inmediatamente después de la preparación del elemento y antes de cualquier otro paso clínico (1,26).

La hibridación dentinaria intenta simular la unión amelodentinaria, se ha comprobado que fomenta y mejora la adhesión y abre una ventana con una mirada hacia las oportunidades y restauraciones dentales biomiméicas, utilizando como sustituto del esmalte y del limite amelodentinario, la porcelana adherida (1,3,25,26).

1.7. Introducción al Sellado dentinario inmediato SDI

En la literatura emerge que en distintas situaciones clínicas hay exposición de tejido dentario sensible a cambios bruscos térmicos o a estímulos ácidos. Son de relevante importancia los resultados aportados por los autores, obtenidos con la técnica de sellado dentinario inmediato.

La técnica de SDI intenta anular la sensibilidad y sellar el tejido impidiendo la filtración de microorganismos en la etapa de los provisionales (1,6).

Se aplica un adhesivo previo a cualquier procedimiento restaurador para no dejar dentina expuesta en un tiempo alargado no controlado (1,6,27,28). Técnica que comprende la imprimación de la dentina recientemente tallada consiguiendo un sellado hermético y una superficie lisa sin contaminaciones antes de la impresión definitiva (1,3,6).

Esta técnica presenta varias ventajas, una de ellas es la polimerización, se indica la pre-polimerización de la resina adhesiva, incrementando la polimerización y la resistencia adhesiva conformando una unión libre de estrés (20,26,29–31).

Estudios han demostrado que la polimerización de la resina completa el desarrollo final de las fuerzas adhesivas y necesita alrededor de una semana. Por otro lado, el uso de este agente resinoso el mismo día que la cementación requiere que el adhesivo se oponga a las fuerzas de contracción del cemento, pero el adhesivo todavía no ha completado la polimerización y la fuerza adhesiva será menor y más susceptible a las fuerzas (26,31).

Aplicar el adhesivo después de haber preparado el elemento dentario, permitirá a la resina llevar completamente acabo la polimerización antes del día de la cementación, creando así la fina interfase adhesiva más resistente a las fuerzas ejercidas sobre ella (3,26).

Otra ventaja del SDI entre los más importantes, es la disminución de la microfiltración bacteriana cuando se cementan coronas con cementos ionoméricos o resinosos (32,33).

Por supuesto aumenta la adhesión y la retención, ventajas que ayudan al manejo clínico cuando se quiere aumentar la retención en elementos excesivamente preparados o muy cortos (34).

La dentina recientemente preparada es descrita como el mejor sustrato de adhesión por sus características (1,3,6,26). Esta técnica mejora el pronóstico final de la restauración en sí y de la resistencia adhesiva que, por otro lado, si se hubiera esperado la cita siguiente, el sustrato de adhesión es probable que hubiese sido contaminado por el uso de cementos provisionales consiguientemente invadido por bacterias resultantes de la preparación dental (20,26,29,34,35).

Otras ventajas del SDI son dirigidas al paciente, como la disminución de la sensibilidad postoperatoria durante el periodo de los provisionales y una probada disminución de sensibilidad post-cementación (12,24,27).

A continuación, se proporciona el protocolo paso a paso mas detalladamente:

1. Después de la preparación del diente, desinfectamos con clorhexidina al 2% durante 30 segundos, lo que nos ayudará a evitar la contaminación de la dentina. Además, lograremos un efecto antibacteriano inactivador de algunos enzimas de la dentina adversos.
2. Una vez lavada y secada la superficie, se elige la resina hidrofilica de un sistema adhesivo autograbante convencional cualquiera (por ejemplo, el Clearfil SE Bond – II). Efectivamente la cantidad dentaria expuesta esta constituida en casi su totalidad por dentina, pudiendo ser factor de riesgo de hipersensibilidad.
3. Sucesivamente aplicaremos la resina hidrófuga, solemos escoger el Optibond FL por su alto contenido de relleno, aplicándola sobre el muñón, lo que nos llevará a la formación de una película de protección mas espesa y resistente. Importante la eliminación de los restos de adhesivo con un pincel o esponjita. Por ultimo se fotopolimeriza durante 20-60 segundos.
4. Finalmente se aísla el adhesivo con glicerina hidrosoluble para eliminar la capa inhibida del oxígeno. Se fotopolimeriza de nuevo durante otros 20-60 segundos. Con el fin de dejar lo mas lisa posible la superficie, se puede utilizar un instrumento reciprocante, como el Profin, para aliviar los excesos en los márgenes.

1.8. Técnicas alternativas "resin coating"

En paralelo al protocolo de P. Magne existe otra técnica alternativa, el resin coating, que lleva la misma finalidad que la técnica anterior: conservar la dentina remanente sana recientemente tallada. En esa técnica a diferencia del SDI se utiliza combinada con el agente adhesivo una resina fluida, ese paso siempre es efectivo si se hace previamente a la toma de impresión definitiva. Eso quiere fomentar el sellado con una micropelícula hibrida hermética (23,36).

Implementar una resina fluida de baja viscosidad, aumenta la resistencia adhesiva elevando también la adhesión del cemento de resina, proporcionando una buena adaptación marginal. Además, ayuda a minimizar la irritación pulpar que se expresa en sensibilidad dentaria (37).

Hoy en día son múltiples los tipos de sistemas adhesivos a disposición del profesional pidiendo al mismo experiencia y estudios para la valoración del uso del adhesivo más congruente a la situación. Por ejemplo, no todos los adhesivos son congruentes con la técnica resin coating (23).

Estudios confirman que esta técnica puede tener un papel importante a la hora de proteger la dentina. Igualmente, los materiales de "protección" tiene el mismo trabajo, eso empuja la odontología adhesiva a ser lo más conservadores posibles, intentando preservar las estructuras dentales remanentes (38). Los beneficiarios al final son las restauraciones, incrementando la fuerza de adhesión tanto en restauraciones directas como indirectas (37–40).

2. Objetivos

2.1. Objetivo principal

El objetivo primario de este estudio es describir la sistemática clínica del sellado dentinario inmediato en prótesis fija y sus ventajas.

2.2. Objetivos secundarios

- Explicar las indicaciones del SDI.
- Identificar el momento más adecuado para llevar a cabo el SDI.
- Comparar los diferentes materiales según la sistemática clínica
- Enumerar técnicas alternativas y eficaces al SDI

3. Metodología

El resultante trabajo fue apoyado al esquema PICO (P: Problema, I: Análisis, C: comparación, O: Resultados), sobre la importancia y efectos del sellado dentinario en restauraciones indirectas adhesivas.
Se buscaron artículos entre el 2002 y el 2020 y otros de relieve histórico por aportar técnicas hoy confirmadas utilizando las bases de datos proporcionados por la Biblioteca CRAI de la Universidad Europea de Madrid.

Se ha llevado a cabo la búsqueda sobre la efectividad del sellado dentinario a través de la análisis de libros, publicaciones de alto impacto y con apoyo bibliográfico de relevancia en la practica clínica moderna.

3.1. Análisis de búsqueda de estudios: estrategia de búsqueda

Se utilizaron los buscadores proporcionados de la base de datos de la Biblioteca CRAI de Universidad Europea de Madrid y los más importantes buscadores científicos electrónicos: Scielo, MedLine, PubMed, Scopus, Web of Science.

Para que la búsqueda resulte más efectiva y rápida se han utilizado las palabras claves: *sellado dentinario; sellado dentinario inmediato; sellado dentinario demorado; sensibilidad postoperatoria; restauraciones indirectas; protocolos de imprimación; dentina; adhesivo*.

3.2. Criterios de inclusión y exclusión

Para satisfacer la demanda de investigación se han propuesto criterios de inclusión y exclusión con el fin de crear figuradamente un grupo de resultados relevantes extrapolados del contenido bibliográfico de referencia.

3.3. Criterios inclusión

La búsqueda de información se basó en la intención de agrupar las informaciones bibliográficas más relevantes con un enfoque reciente. Se han elegido investigaciones que contienen información sobre el efecto real del sellado dentinario inmediato, de libros y artículos con respaldo bibliográfico.

3.4. Criterios exclusión

Se descartó información de series de casos, cartas, comunicaciones cortas, posters, resúmenes de conferencias y artículos que no contienen información actualizada o que sus aportes no estén respaldados con fuentes bibliográficas.

3.5. Recogida de datos

Los datos adquiridos provienen de la búsqueda inicial de 120 artículos, posteriormente analizados para valorar la importancia que podría aportar al tema de búsqueda.

Se eliminaron 34 títulos después haber leído titulo y resumen siendo estos ajenos a nuestro trabajo y otros 30 por no aportar la información actualizada o no corresponder a publicaciones de alto impacto.

Siguiendo la información reunida se sugirió trasformar las informaciones de mayores importancias en tablas.

Unas de las preguntas más importantes son:

a. ¿Cómo se realiza un SDI?
b. ¿Cuándo se debe realizar un SDI?
c. ¿Cuándo es el momento más conveniente para realizar un SDI?
d. ¿Cuál es el material de elección para efectuar la técnica de SDI?
e. ¿Cuáles son los beneficios primarios que aporta el SDI?

   Por último, realizamos un estudio cualitativo para adquirir las respuestas a las demandas propuestas.

4. Resultados

Basándose en la información obtenida, se puede afirmar que el SDI es un procedimiento esencial y funcionalmente útil siempre que se realice una preparación a nivel dentinario (1,28). El elemento será candidato a una restauración indirecta protésica como incrustaciones, coronas, carillas, dejando gran cantidad de dentina expuesta: ésta debe ser protegida y cubierta inmediatamente.

Se han analizado varios estudios para poder identificar el momento indicado para realizar el protocolo de sellado dentinario, se han aclarado paso a paso los protocolos de SDI y sellado dentinario retardado o demorado: SDD (**Tabla 1**) (41–43).

Analizados los datos resulta que 6 artículos responden directamente a la pregunta antedicha, podemos determinar siguiendo los valores que la mayoría de los autores sugieren la técnica de sellado dentinario inmediato, antes de las impresiones definitivas, aprovechando el excelente sustrato para fomentar nuestra adhesión y defender el elemento.

El 83,3% de los autores (5 sobre 6) están de acuerdo confirmando que el mejor momento para realizar un SD es inmediatamente después de la preparación del mismo diente. (**Tabla 2**) (5,41,44–46).

También se investiga cuál podría ser el mejor material para la realización del sellado dentinario inmediato (**Tabla 3**). A este propósito, A. Díaz, J. de Munck y P. Magne coinciden en afirmar que Optibond FL desarrolla una fuerza adhesiva mayor 49,42 Mpa, comparado con otro sistema adhesivo, el Clearfil SE Bond, con valores dos de 45,42 Mpa (41–43).

Se comparan y analizan otros dos sistemas adhesivos: Adper Single Bond 2 con valor de resistencia adhesiva de 24,12 Mpa, One Coat SE Bond con valores de resistencia adhesiva de 19,93 Mpa de media (46).

Tras analizar los datos recogidos, se constató que el 85% (17 autores sobre 20) de los autores afirman que según el protocolo de SDI la sensibilidad dental disminuye. En un 60% (12 autores sobre 20) los autores confirman que el protocolo de SDI fomenta un aumento y mejora la adhesión. Sólo un 5% (1 autor sobre 20) de los autores afirman que hay una bajada de la microfiltración bacteriana.

Se intentó por último reunir las informaciones de los artículos esquematizándolas para dibujar un protocolo accesible a todos y una buena alternativa a esta técnica (**Tabla 4**).

Tabla 1. Cuadro protocolo de sellado dentinario previo o posterior a la impresión definitiva y la cementación de provisionales.

Sellado dentinario demorado (SDD)	Sellado dentinario inmediato (SDI)
1. Preparación del elemento dental.	1. Preparación del elemento dental.
2. Impresión definitiva.	2. SDI.
3. Confección y cementación temporal del provisional.	3. Impresión definitiva.
4. Retirada del provisional.	4. Confección y cementación temporánea del provisional.
5. Valoración del sustrato / Evaluación preparación.	5. Retirada del provisional.
6. SDD.	6. Valoración del sustrato / Evaluación preparación.
7. Cementación restauración definitiva.	7. Cementación restauración definitiva.
Fuentes: elaboración propia a partir de 6 apellidos de los autores (8,12,27,48,55,62)	

Tabla 2. Criterios de autores diferentes del momento para realizar el sellado dentinario inmediato

Autor	Previo a las impresiones	Previo a la cementación
E. Padros (22)	SDI	
S. Duarte (44)	SDI	
P. Magne (41)	SDI	
A. Qanungo (5)	SDI	
M. Nawareg (45)	SDI	
J. Colina (46)		SDD
Fuente: elaboración propia a partir de 6 apellidos de los autores.		

Tabla 3. Materiales utilizados en el protocolo de SDI, resistencia adhesiva Mpa

Autor	Material	Resistencia
A. Matos, P. Magne, J. de Munck (41–43)	Clearfil SE Bond,	45, 42 Mpa
P. Magne, A. Diaz, J. de Munck (41–43).	Optibond FL	49, 42 Mpa
J. Colina (46)	Adper Single Bond 2	24,12 Mpa
J. Colina (46)	One Coat self- Etching	19,93 Mpa
Fuente: elaboración propia a partir de 5 apellidos de los autores.		

Tabla 4. Protocolo SDI, variante SD resin coating.

Optibond FL (SDI)	Resin Coating
Aplicar acido ortofosforico 37% 5” en la dentina recién cortada.	Aplicar ácido ortofosforico al 37% 5” en dentina recién cortada.
Lavar con agua el doble del tiempo.	Lavar con agua el doble del tiempo.
Secar suavemente sin desecar.	Secar sin desecar.
Aplicar el primer (Optibond FL Prime) durante 25-30” y secar durante 5”.	Aplicar el primer durante 25-30” y secar durante 5”.
Aplicación del bonding (Optibond FL) frotando la superficie 15”.	Aplicación del onding frotando la superficie 15”.
Fotopolimerización 20”.	Fotopolimerización 20”.
Cubrir la superficie con glicerina y fotopolimerizar 20”	Colocar la resina fluida y fotopolimerizar 20”.
Alivio de márgenes externos.	Cubrir la superficie con glicerina y fotopolimerizar 20”.
Fuente: elaboración propia a partir de 3 apellidos de los autores (6,23,46)**.**	

5. Discusión

Este trabajo de revisión bibliográfica tiene por objetivo informar y explicar la eficacia clínica del sellado dentinario y resaltar su importancia tras la cementación de restauraciones indirectas, destacando su efecto positivo sobre problemáticas comunes como la sensibilidad postoperatoria.

Comentado por los autores existen dos métodos discordantes en el momento en que se tiene que realizar el SD: en caso de elegir el SDD, se aplicaría el agente adhesivo antes de la cementación definitiva, mientras que con la técnica SDI, se procedería a este paso antes de la impresión final (6,11,27,41,47).

En los artículos estudiados, J. Colina y cols. comparan los dos protocolos, confirmando que entre los dos procedimientos, la técnica tradicional de SDD es, hoy en día, algo obsoleta y superada por el SDI, con respecto a fuerza y durabilidad (46).

De hecho, muchos autores sugieren sellar la dentina inmediatamente después de la preparación del elemento y previamente a la impresión final. Esto porque la dentina recientemente cortada representa un sustrato óptimo que, por su sensibilidad a la adhesión, permite la penetración del agente adhesivo en los túbulos, creando, de esta manera, una unión sólida (26–28,48).

Además, en un estudio de investigación, P. Magne y cols. han demostrado que la proporción de la resistencia adhesiva entre SDI y SDD es, respectivamente de 5:1; resultados parecidos han sido propuestos por E. Padros y S. Duarte que, en sus estudios, confirman que la resistencia se ve mejorada con el procedimiento de SDI (1,22,44).

Asimismo, las investigaciones de P.Magne han demostrado que la técnica de sellado dentinario demorado o pospuesto no garantiza un sustrato adecuado para la adhesión de la futura cementación definitiva (24,27). La causa, es la dentina que se expone a los factores contaminantes haciendo colapsar las fibras de colágeno, junto a una no conforme capa hibrida, proporcionando así un descenso de los valores de resistencia y fuerza adhesiva entre la restauración y el elemento dentario (49).

En los artículos emerge que la aplicación de un sistema adhesivo ya sea de tres pasos con lavado o de dos pasos autograbante, llevará como resultado una unión comparable a la misma obtenida con un agente adhesivo recientemente aplicado (5,41,42,44).

Con respecto a la selección de los adhesivos y los materiales útiles para lograr un sellado dentinario eficaz, los especialistas en rehabilitación oral tienen una amplia gama entre los cuales elegir, pero no todos sirven para este propósito.

J. Colina en su estudio compara diferentes sistemas de unión, destacando los distintos valores de resistencia adhesiva. Entre ellos, el adhesivo One Coat SE fue el que menos resistencia ha desarrollado, con valores de 19,93 Mpa. Por otro lado, el adhesivo de grabado total de dos pasos, el Adper Single Bond 2, resultó ser levemente más eficaz (24,12 Mpa) (46). Sin embargo, el uso del adhesivo Adper Single Bond 2, tras los resultados aportados por el estudio de Duarte y cols., no demostró la eliminación completa de microfiltración (44).

Por otro lado, el Clearfil SE Bond 45,42 Mpa fue el que mejor resistencia adhesiva tuvo (46).

En el estudio de F.J. Gil-Loscos y cols. se ha evidenciado como, de los tres grupos de adhesivos estudiados, el Clearfil SE Bond pertenecía al segundo grupo que mejores resultados obtuvo (50).

Con respecto a la polimerización de los adhesivos, P. Magne y cols en 2009 destacaron que la cantidad de capa inhibida fue notablemente diferente entre Optibond FL y Clearfil SE Bond. Mientras que el Optibond FL dejó una capa de resina lisa, el Clearfil SE Bond se caracterizó por más irregularidades en la superficie. Consecuentemente, el primero obtuvo resultados positivos, sin defectos estructurales a la hora de analizar las impresiones (41).

Además, J. de Munck, en un estudio sobre 55 elementos dentarios no cariados, tras la preparación del diente, trata la superficie expuesta con tres adhesivos: de autograbado de un solo paso, AQ bond, Reactmer y Xeno CF Bond, dos adhesivos de autograbado de dos pasos, ABF experimental y Clearfil SE Bond, un adhesivo de grabado total de dos pasos, Prime & Bond NT, y un adhesivo de grabado total de tres pasos, OptiBond FL. Sus resultados confirmaron que, en comparación con la resistencia adhesiva de dentina, sólo OptiBond FL se comportó significativamente mejor que los adhesivos de autograbado de un solo paso (43).

Por otro lado, A Qanungo, nos proporciona mas información sobre este adhesivo de tres pasos y, tras los resultados del estudio, apreciamos que el OptiBond FL presentó un espesor de película más uniforme que los adhesivos sin relleno (5).

Analizando los datos proporcionados por la literatura podemos destacar la importancia de este procedimiento y convertirlo en una base sólida para el éxito de una restauración indirecta.

En la **Tabla 5** se intenta representar las principales ventajas del sellado dentinario inmediato según la literatura. Concordando con los criterios sugeridos de los autores, se puede afirmar que la principal ventaja que proporciona el procedimiento de SDI es la permeabilización de la dentina durante el periodo provisional y la consecuente disminución de la sensibilidad postoperatoria. Además, es evidente por la elevada relevancia bibliográfica, que esta técnica aumente la capacidad de adhesión.

Tabla 5. Beneficios del sellado dentinario inmediato:

Autor	Depreciación Sensibilidad	Mejora la adhesión	Reduce infiltración bacteriana
E. Padros (22)	x	x	
S.Duarte (44)	x		
K.Arquiñejo (47)	x	x	
P. Magne (27)	x	x	
M. Nakabayashi (25)		x	
R. Leesungbok (51)	x		
J. de Munck (43)		x	
P. Magne (41)	x	x	
A.Quanungo (5)	x	x	
G. Francisco (50)	x		
K. Hayashi (52)	x	x	
Y.S. Choi (48)	x		
B. van Meerbeek (16)	x	x	
J. Colina (46)	x	x	x
A. Matos (42)	x		
M Stavridakis (53)	x	x	
R. Dalby (54)	x	x	
D. Brigagão (55)	x		
V. Santana (56)	x		
D.H. Pashley (12)			x
Fuente: elaboración propia a partir de 20 apellidos de los autores.			

6. Conclusiones

- El SDI resulta ser un protocolo fiable y eficaz, que ayuda a alejarse de los efectos secundarios causados por la sensibilidad dentaria, derivada a su vez por la inmigración bacteriana durante el período provisional. Se obtiene como resultado la protección del órgano dentino-pulpar y la mejora de la adhesión.

- La realización del SDI está indicada y aconsejada en la condición en que haya cantidad de dentina expuesta en proporción con la preparación del elemento, que se traduce como adhesión de la restauración protésica sucesivamente cementada.

- La indicación para realizar un SDI es previo a las impresiones y debe producirse inmediatamente después de la preparación dentaria para poder aumentar la fuerza de adhesión, utilizando a nuestra ventaja la misma anatomía dentaria recientemente preparada.

- El mundo comercial de los adhesivos dentarios es muy amplio y en continuo desarrollo generacional, añadiendo características como una mejora en la tensión y la compatibilidad. El material que reúne las características requeridas para la realización de esta técnica es Optibond FL con carga, que dará la capacidad al adhesivo de crear una película uniforme.

- Por último, se puede concluir que P. Magne ha aportado el protocolo estándar para la técnica SDI y, además, se ha mencionado como alternativa la técnica "resin coating", válida para lograr del objetivo de sellar la dentina para que sea impermeable a factores contaminantes.

Concluyendo, en el siguiente estudio se pesaron los resultados de las dos técnicas de "defensa" del complejo dentino pulpar: SDI y resin coating, confirmando su uso en la clínica odontológica moderna. En primer lugar, debe haber un operador capaz, preparado y dispuesto a cambiar el protocolo según el sustrato y el material utilizado, modificando así en particular el tiempo de grabado o la extensión de la preparación. En segundo lugar, es fundamental el tipo de material y por último la técnica empleada será un factor determinante para el resultado del tratamiento. El tema imprescindible es la capa hibrida, elemento clave para la creación de la interfase que requiere ser a la vez resistente y duradera en el tiempo, y que de misma manera, debe imitar una estructura de unión natural y de compleja arquitectura entre el esmalte y dentina. No hay que olvidar que los adhesivos no son permanentes, sino que se degradan con el tiempo, sin embargo, se continuará buscando la combinación correcta para obtener los resultados requeridos por el elemento resinoso de unión asegurando mayor vida a nuestras restauraciones.

7. Responsabilidades

Este trabajo tiene una gran importancia a nivel social, ya que la demanda del paciente es siempre más alta y el margen de error es siempre más bajo. La estética sigue siendo un peso psicológico fundamental para el paciente y por lo tanto para el resultado final de la prótesis. Para atenerse a la solicitud, la odontología mínimamente invasiva contempla el uso de restauraciones de mínimo espesor que requieren a su vez una atención al microscópico. Todo esto pesa sobre los hombros de una correcta adhesión que debe ser "ultrafina" y al mismo tiempo resistente.

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9. Anexos:

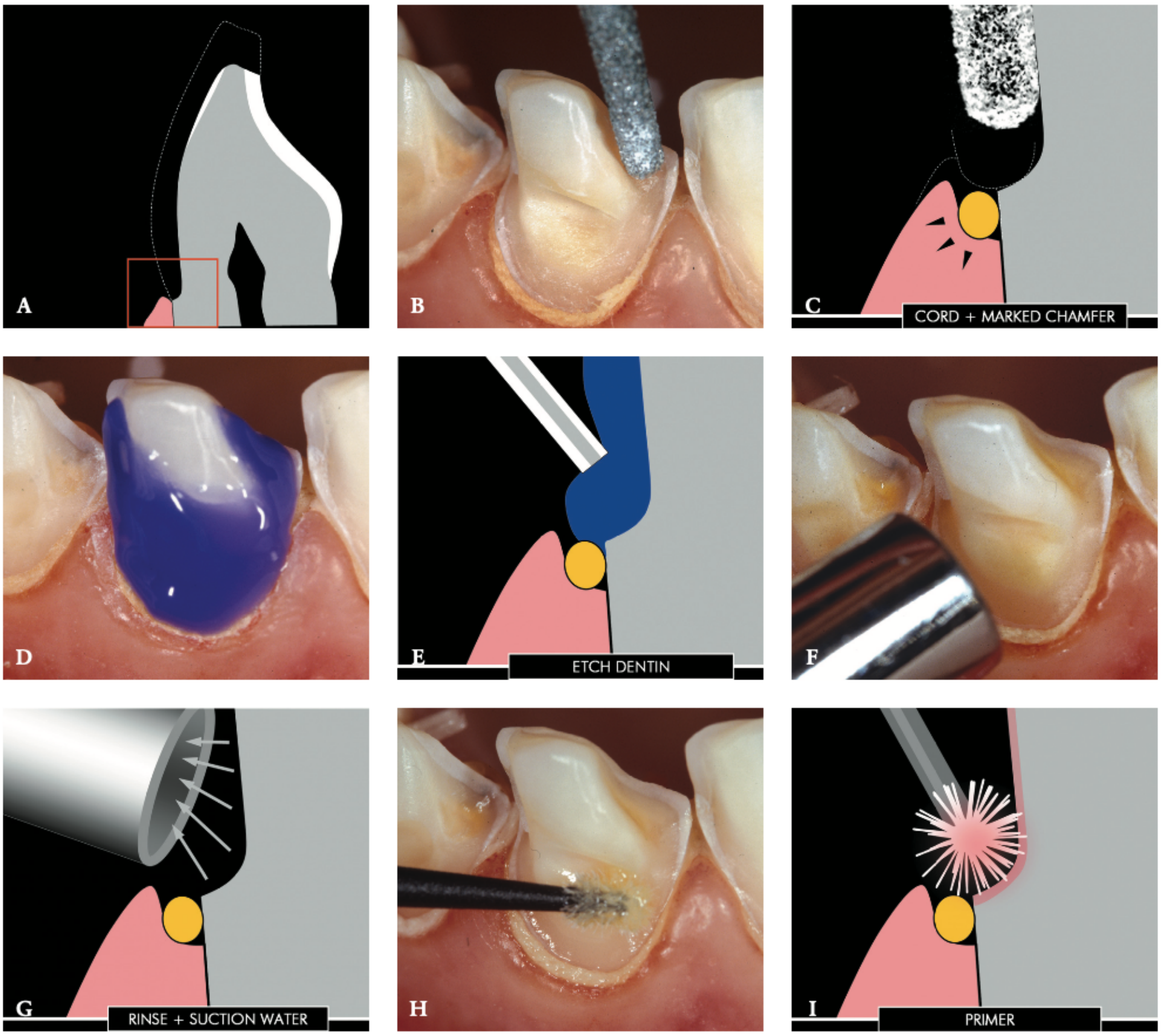

*Figure 2. A, Immediate dentin sealing is particularly challenging when dealing with dentin margins in veneer preparations for anterior teeth (*red rectangle *shows the schematic cross-sectional view of gingival dentin margins in images C, E, G, I, J, L–N, and P–S). B, Clinical situation during preparation of eroded teeth. Existing restorations, as well as severe initial erosion and wear, led to the realization of a shoulder facial preparation. C, A marked gingival chamfer always facilitates the application of the dentin bonding agent. Immediate dentin bonding would not be possible in the presence of a traditional light chamfer because the adhesive layer tends to pull over the margin, creating a feather-edge finish line and insufficient margin definition. D and E, Immediately following tooth preparation, uncontaminated dentin surfaces are etched for 5 to 15 seconds (depending on the adhesive system used). It is recommended to extend etching 1 to 2 mm over the remaining enamel to ensure further adhesion of eventual excess resin. F and G, Following abundant rinsing, excess water is suctioned. Direct contact between dentin and the suction tip must be avoided. H and I, The priming agent (hydrophilic monomer, eg, bottle 1 in OptiBond FL) is applied to dentin with a gentle brushing motion for at least 20 seconds. Several applications of fresh primer are recommended.*

Magne P. (2005). Immediate dentin sealing: a fundamental procedure for indirect bonded restorations. *Journal of esthetic and restorative dentistry : official publication of the American Academy of Esthetic Dentistry ... [et al.]*, *17*(3), pag. 151. https://doi.org/10.1111/j.1708-8240.2005.tb00103.x

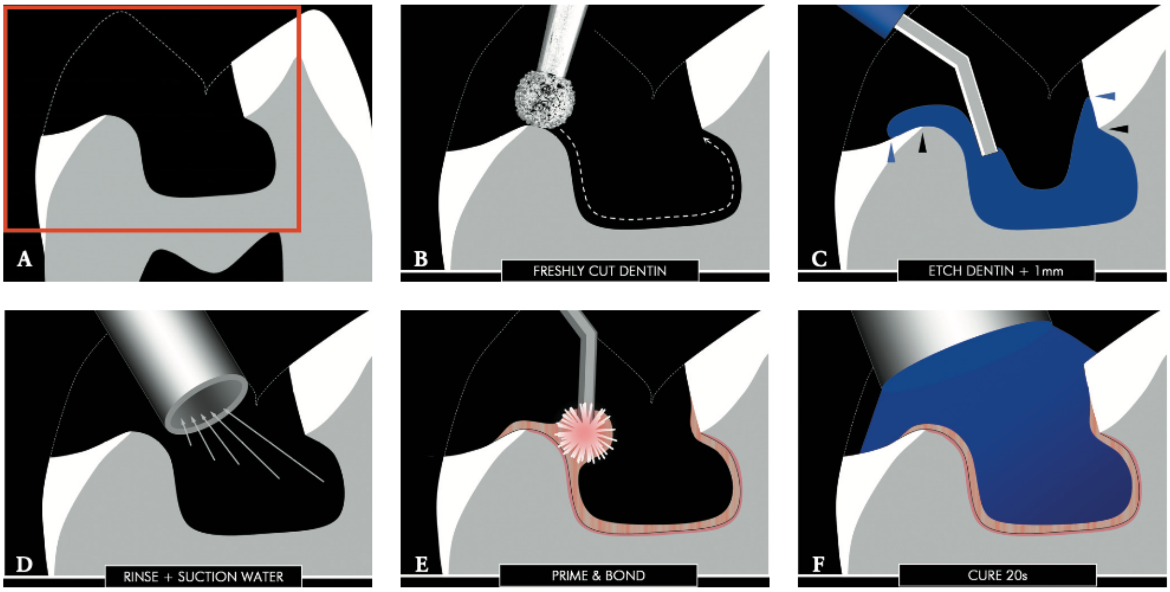

Figure 3. A, *Schematic cross-sectional view of the posterior tooth following amalgam/decay removal and simulating partial cusp coverage (*red rectangle *shows the magnified view used for images B–K).* B, *Immediate dentin sealing can be carried out independently of the occlusal enamel margin configuration, and retentive areas can be ignored initially. The application of the dentin bonding agent should always start by freshly cutting the exposed dentin surface.* C, *The freshly cut dentin surface is etched for 5 to 15 seconds (depending on the adhesive system used). It is recommended to extend etching 1 to 2 mm over the remaining enamel.* D, *Following abundant rinsing, excess water is suctioned.* E, *In cavities with enamel margins only, a two-step dentin bonding agent can be used (eg, OptiBond Solo).* F, *The adhesive is cured for 20 seconds.*

Magne P. (2005). Immediate dentin sealing: a fundamental procedure for indirect bonded restorations. *Journal of esthetic and restorative dentistry : official publication of the American Academy of Esthetic Dentistry ... [et al.]*, *17*(3), pag. 152. https://doi.org/10.1111/j.1708-8240.2005.tb00103.x

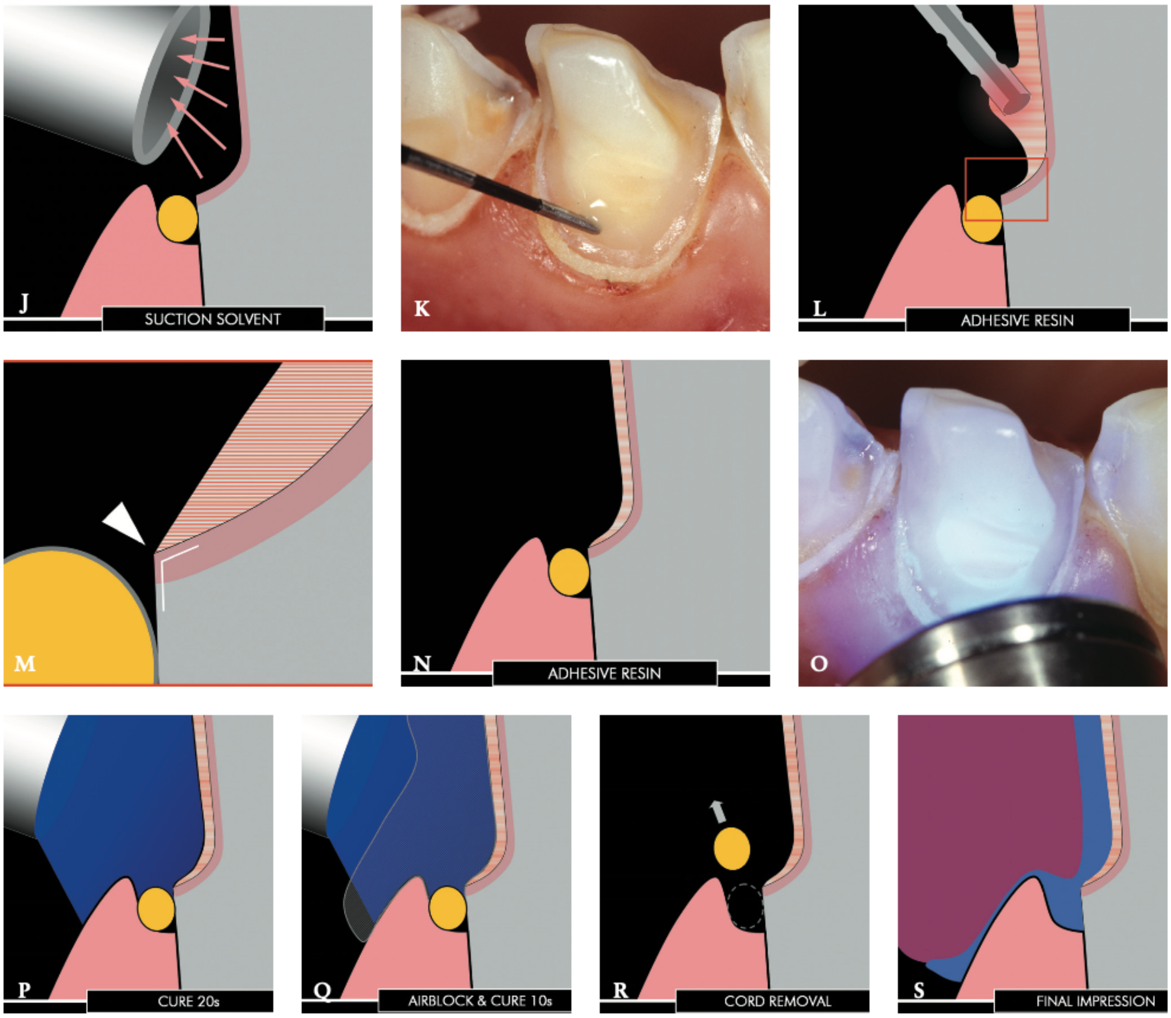

Figure 2 continued. J, *The dentin surface is suctioned again to eliminate the solvent (eg, alcohol in the case of OptiBond FL primer) from the priming solution.* K, *The adhesive (eg, bottle 2 in OptiBond FL) is applied with precision using a drop of resin on the tip of a periodontal probe. Direct contact between dentin and the tip of the probe should be avoided. The probe is used to help spread the adhesive to the edges of the exposed dentin.* L, *The adhesive is left to diffuse along the chamfer. The tip of the probe should not approach the margin more than 0.5 mm to avoid pulling of the resin* (red rectangle *shows a magnified view of gingival dentin margins seen in image M).* M, *Because of surface tension phenomenon, the adhesive spreads onto the primed dentin surface but is arrested at the sharp edge of the margin.* N, *Owing to the original deep chamfer, the definition of the margin is not affected by the presence of the adhesive layer.* O *and* P, *The adhesive can be cured, first for 20 seconds.* Q, *A thick layer of glycerin jelly is applied to the sealed surface and beyond, and another 10 seconds of light curing is applied to polymerize the air-inhibited layer of the resin. Glycerin can be removed easily by rinsing.* R, *In the presence of clean margins, the deflection cord should be removed easily. Excess resin is usually detected at this stage because of adhesion between the tooth and the cord.* S, *The impression is carried out, preferably with a one-step, double-mix technique: low-viscosity material injected onto the preparation (*blue*) and more heavy material from the tray (*purple*).*

Magne P. (2005). Immediate dentin sealing: a fundamental procedure for indirect bonded restorations. *Journal of esthetic and restorative dentistry : official publication of the American Academy of Esthetic Dentistry ... [et al.]*, *17*(3), pag. 153. https://doi.org/10.1111/j.1708-8240.2005.tb00103.x

The Dual Bonding Technique: A Modified Method to Improve Adhesive Luting Procedures

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Indirect restorative procedures usually require temporary restorations for protection of the pulp and for restoring the patients esthetic and functional needs. The use of temporary cements, either with or without eugenol, however, considerably decreases the adhesion of the bond on dentin if—according to the conventional technique—such dentin bonding systems are applied once at the moment of final cementation. With a dual application of the dentin bonding agents a considerable increase in bond strength values was discovered. This article presents a modified luting procedure called the "dual bonding technique." (Int J Periodont Rest Dent 1997;17:537–545.)

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Indirect restorations usually require a provisional restoration that is luted to the abutment tooth with a temporary cement. Very discouraging and sometimes very confusing results have been reported when the shear bond strength of dentin bonding agents was measured on dentin that had been contaminated with provisional cements prior to the bonding procedure.[1] In some cases the bond strength values were increased, in other cases they were decreased. An explanation for such varying results was difficult and led to disagreement.

An attempt to improve the cleaning of the dentinal surface after application of temporary cements was undertaken with the use of soaps.[2] The results were again discouraging, probably because cleaning the dentin with soap resulted in the subsequent inability of the dentin bonding agents to wet the dentinal surface.

ORIGINAL ARTICLE

Postoperative Sensitivity of Self Etch Versus Total Etch Adhesive

Ajmal Yousaf[1], Nadia Aman[2], Manzoor Ahmed Manzoor[1], Jawad Ali Shah[1] and Dilrasheed[1]

ABSTRACT

Objective: To compare postoperative sensitivity following composite restoration placed in supra gingival class-V cavities using self etch adhesive and total etch adhesive.

Study Design: A randomized clinical trial.

Place and Duration of Study: Operative Dentistry Department of Armed Forces Institute of Dentistry, Rawalpindi, from July to December 2009.

Methodology: A total of 70 patients having class-V supra gingival carious lesions were divided into two groups. Classes-V cavities not exceeding 3 mm were prepared. One treatment group was treated with self etch adhesive (adhe SE one Ivoclar) and the control group was treated with total-etch adhesive (Eco-Etch Ivoclar) after acid etching with 37% phosphoric acid. Light cured composite (Te-Econom Ivoclar) restoration was placed for both groups and evaluated for postoperative sensitivity immediately after restoration, after 24 hours and after one week. Data was recorded on visual analogue scale.

Results: Comparison of sensitivity between the two treatment groups on application cold stimulus after 24 hours of restoration showed significant difference; however, no statistically significant difference was observed at baseline, immediately after restoration and at 1 week follow-up with cold stimulus or compressed air application.

Conclusion: Less postoperative sensitivity was observed at postoperative 24 hours assessment in restoration placed using SE adhesives compared to TE adhesives. Thus, the use of SE adhesives may be helpful in reducing postoperative sensitivity during 24 hours after restoration placement.

Key Words: *Dentin-bonding agents. Dentin sensitivity. Composite dental resin.*

INTRODUCTION

Postoperative sensitivity after placing composite restoration has been a significant problem experienced by clinicians. This has been attributed to several factors including dentine etching, restoration technique, over-drying of dentin, polymerization shrinkage, depth of cavity and deformation of the cusps by occlusal forces.[1-4]

Bonding to dentine has traditionally relied on three steps; conditioning, priming and bonding. Total etch (TE) dentine is a widely used generation of dentin adhesive. In attempts to decrease the number of steps and subsequent more chances of procedure errors in dentin bonding has led to development self etch (SE) adhesives.[5,6] SE adhesives eliminates the need for separate acid etching/conditioning step and subsequent rinsing and drying of dentin. Over drying of dentin can lead to collapse of collagen meshwork in conditioned dentin and may lead to postoperative sensitivity and decrease in bond strength. The reduction in number of steps in SE adhesives can lead to decrease in chair-side time and by avoiding potential overdrying it may also lead to lesser postoperative sensitivity.[7] Some studies have reported equivocal results for postoperative sensitivity and dentin bond strength for method of application and adhesive used.[8,9]

The objective of this study was to compare the postoperative sensitivity of class-V restoration placed with self etch adhesive and total etch adhesive.

METHODOLOGY

The patients reporting to Operative Dentistry Department of AFID, from July to December 2009, were screened by taking history, clinical examination and pulp vitality tests. The study was conducted after approval from the Ethics Review Committee. Written informed consent was taken from patients willing for enrollment in study after briefing of the aim of study and its methods.

Patients of either gender, aged 18-44 years, presenting with class-V carious lesion on buccal surface of anterior and premolar teeth were included. The vitality status was ascertained on thermal testing of teeth to rule out pulpal necrosis and irreversible pulpitis. Patients with parafunctional habits, generalized sensitivity, poor periodontal health and who were on desensitizing treatment were excluded.

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Clinical Research

Clinical Assessment of Postoperative Sensitivity in Posterior Composite Restorations

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AK Bedran-Russo • RS de Alexandre • GMB Ambrosano

Clinical Relevance

Posterior teeth restored with resin composite have been known to exhibit postoperative sensitivity. The type, size and design of the cavity, material properties and handling technique may influence the incidence of this sensitivity.

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SUMMARY

This incidence of postoperative sensitivity was evaluated in resin-based posterior restorations. Two hundred and ninety-two direct restorations were evaluated in premolars and molars. A total of 143 Class I and 149 Class II restorations (MO/OD and MOD) were placed in patients ranging in age from 30 to 50 years. After the cavity preparations were completed, a rubber dam was placed, and the preparations were restored using a total-etch system (Prime & Bond NT) and a resin-based restorative material (TPH Spectrum). The patients were contacted after 24 hours and 7, 30 and 90 days postoperatively and questioned regarding the presence of sensitivity and the stimuli that triggered that sensitivity. The Chi-square and Fisher's Exact Test were used for statistical analysis. Evaluation at 24 hours after restorative treatment revealed statistically significant differences among the types of cavity preparations restored and the occurrence of postoperative sensitivity (*p*=0.0003), with a higher frequency of sensitivity in Class II MOD

A SIMPLE METHOD OF INCREASING THE ADHESION OF ACRYLIC FILLING MATERIALS TO ENAMEL SURFACES

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ONE of the major shortcomings of the acrylics and other filling materials is their lack of adhesion to tooth structure.[1-4] A filling material capable of forming strong bonds to tooth structures would offer many advantages over present ones. With such a material, there would be no need for retention and resistance form in cavity preparation, and effective sealing of pits, fissures, and beginning carious lesions could be realized.

In our attempts to obtain bonding between filling materials and tooth structure, several possibilities are being explored. These include (1) the development of new resin materials which have adhesive properties; (2) modification of present materials to make them adhesive; (3) the use of coatings as adhesive interface materials between filling and tooth; and (4) the alteration of the tooth surface by chemical treatment to produce a new surface to which present materials might adhere.

This last approach is the subject of this paper, but since it concerns itself only with treatment of intact enamel surfaces, it has only limited application to the broader problems of restorative dentistry.

In industry, phosphoric acid and preparations containing it have been used to treat metal surfaces to obtain better adhesion of paint and resin coatings.[5] Although the increased adhesion is believed to be due primarily to the removal of surface and other contaminants, the conversion of the oxides or the surface of the metal itself to phosphates or the adsorption of phosphate groups on the metal surface may contribute to the effect. Since the enamel surface has probably reacted with various ions, saliva, and so on, to which it has been exposed for long periods of time, and its tiny imperfections filled in by a variety of adventitious materials, the composition of the superficial surface may be quite different than the underlying enamel.[6] As a result, any receptivity to adhesion which the original tooth structure may have had for acrylic materials may have been lost. It was felt that perhaps an acid treatment of the enamel surface might render it more receptive to adhesion in the same manner as it does for metals.

EXPERIMENTAL

Two methods were used for treating the enamel surfaces. The first involved the use of a 50 per cent dilution of a commercial phosphomolybdate

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¿Son los adhesivos dentinarios una opción válida para el tratamiento de la sensibilidad cervical dentinaria?

Gil-Loscos, Francisco José

Are dentin bonding systems a valid option for the treatment of Cervical Dentin Sensitivity (C.D.S.)?

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Resumen: El objetivo de este trabajo es evaluar la capacidad *in vitro* de sellar túbulos dentinarios y reducir la permeabilidad dentinaria que tienen catorce productos propuestos para el tratamiento de la sensibilidad cervical dentinaria (SCD) y evaluar el efecto que la humedad y el cepillado tienen sobre ellos.
Material y método: 140 discos de dentina (obtenidos de 3º molares humanos recién extraídos) se dividen en catorce grupos de 10 discos que se montan en un sistema de perfusión basado en la máquina de Pashley que mantiene una presión positiva sobre los discos. Cada disco se graba con ácido ortofosfórico al 35% y su permeabilidad se mide en una hora, este valor se considera el de referencia (100%). Un disco queda como control y se aplica tratamiento a los otros 9, midiéndose su permeabilidad en una hora. Después se deja un disco como control, a los 8 restantes se les realiza un lavado y cepillado, viéndose su permeabilidad en una hora.
Resultados: Todos los productos afectaron a la perfusión dentinaria en mayor o menor grado. El cepillado de las muestras con el producto aplicado afectó a la permeabilidad, que en todas las preparaciones aumentó en mayor o menor grado. El mejor producto fue el Seal & Protect, seguido del Amm-i-dent + Xeno III, el Clearfil SE Bond y el Amm-i-dent + Scotchbond1.
Conclusiones: Todos los productos presentan mala resistencia al lavado y cepillado, lo que justifica el limitado éxito clínico de los agentes desensibilizantes. El que los cuatro mejores productos o combinaciones en cuanto a reducción de permeabilidad pertenezcan al grupo de los adhesivos dentinarios indica que estos pueden ser una alternativa válida para ser investigada y perfeccionada como tratamiento de la SCD.

Palabras clave: Sensibilidad dentinaria, Adhesivo dentinario, Permeabilidad Dentinaria

Abstract: The aim of this study is to evaluate the "in vitro" capability of fourteen agents proposed for the treatment of cervical dentin sensibility (CDS) to seal dentine tubules, to reduce dentine permeability and to resist the effect of wetness and tooth brushing.
Materials and Methods: 140 dentin discs were obtained from freshly extracted human third molars. Samples were divided into fourteen groups of 10 each and were mounted in a perfusion device based on the Pashley´s system. Each disc was etched with 35% phosphoric acid. Permeability was measured after 1 hour, this value was considered the reference value (100%). One disc was used as a control and nine were treated with a bonding system. Permeability was measured again after 1 hour. One disc was used as a control and 8 were washed with water and subjected to simulated tooth brushing equivalent to three weeks of normal brushing. Subsequebtly, permeability was measured again.
Results: All systems reduced dentinal perfusion when applied. Brushing of products produced an increase of permeability. The best results were obtained with Seal & Protect, follwed by Amm-i-dent + Xeno III, Clearfil SE Bond and Amm-i-dent+Scotchbond 1.
Conclusions: All products have shown low resistance to washing and brushing. This can justify unsatisfactory clinical results in reducing dentinal sensibility. The best four products were all adhesives or a combination of these, it seems to indicate that adhesives are a good choice to be investigated and improved for the treatment of CDS.

Key words: Dentin sensitivity, Bonding system, Dentin Permeability

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ESTUDIO COMPARATIVO DE LA FUERZA DE ADHESIÓN DE DOS SISTEMAS ADHESIVOS EN LAS TÉCNICAS SDD Y SDI.

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RESUMEN

Comparar la influencia del sellado dentinario inmediato (SDI) usando adhesivos dentinarios de grabado total y autograbadores en la resistencia adhesiva (µBts) a dentina de restauraciones indirectas de composite. 40 molares humanos sanos se desgastaron hasta exponer la dentina del tercio medio coronal. Estos molares se asignaron aleatoriamente a cuatro (4) grupos experimentales (n=10) de acuerdo con la técnica de cementación utilizada para la restauración indirecta de composite. G1: sellado dentinario demorado con sistema adhesivo de grabado total Adper Single Bond 2 (SDD+SB2); G2: sellado dentinario demorado con sistema adhesivo autograbador One Coat Self-Etching Bond (SDD+OCB); G3: sellado dentinario inmediato con sistema adhesivo de grabado total Adper Single Bond 2 (SDI+SB2); G4: sellado dentinario inmediato con sistema adhesivo autograbador One Coat Self-Etching Bond (SDI+OCB). Las muestras se seccionaron en una sierra de precisión ISOMET 1000™ (Buehler) para obtener varios microespecímenes, las cuales se sometieron a tracción en una máquina de pruebas universales a una velocidad de 1mm/seg hasta que se fracturo. Los valores obtenidos en MPa fueron analizados con un ANOVA univariado (µBts) de dos factores (adhesivo y técnica de sellado dentinario) contenido en el paquete estadístico SPSS 19.0™; se estableció el valor de $p \leq 0,05$. µBts nivel adhesivo $p=0,006$; con diferencias significativas. Las medias en rechazo a MPa y desviación estándar (SD±) fueron: SB2 (G1+G3): 24,12(9,7) > OCB (G2+G4): 19,33(8,35). µBts nivel técnica de sellado dentinario $p=0,005$; con diferencias significativas. SDI (G3+G4): 24,19(10,02) > SDD (G1+G2): 19,26(7,92). El tipo de adhesivo no influyó de manera significativa ($p=0,300$) con el tipo de sellado dentinario. El sistema SB2 arrojó mayores valores de fuerza de adhesión a dentina que el sistema adhesivo OCB. El SDI aumenta significativamente los valores de adhesión a dentina para ambos sistemas adhesivos.

Palabras clave: Sellado dentinario inmediato, sellado dentinario demorado, fuerza adhesiva, grabo total, autograbador.

Postoperative Sensitivity in Class I Composite Resin Restorations in vivo

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Purpose: This study evaluated the postoperative sensitivity of posterior Class I composite resin restorations, restored with a self-etching or a total-etch one-bottle adhesive system.

Materials and Methods: One hundred four restorations were replaced by one clinician in 52 patients. Each patient received two restorations. After cavity preparations were completed under rubber-dam isolation, they were restored using Clearfil SE Bond or Single Bond and a resin-based restorative material (Filtek Z250). Sensitivity was evaluated at 0 and 7 days and 6 months using cold stimuli, and recorded using a visual analogue scale. If sensitivity was experienced on day 7, patients were also contacted on days 14 and 30 to assess the degree of sensitivity. The scores were analyzed as nonparametric data by means of the Friedman and Wilcoxon tests.

Results: No statistically significant differences in sensitivity were found between the two adhesives systems at days 0 and 7 or at 6 months. No spontaneous postoperative sensitivity was reported.

Conclusions: The adhesives systems used in this study showed no differences in postoperative sensitivity, and did not show spontaneous sensitivity after 6 months.

Keywords: postoperative sensitivity, adhesive system, composite resin.

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Manhart et al[12] observed that 60% of restorations are replacements. Many authors have given the following reasons for replacement: secondary caries, inadequate anatomical form, poor surface texture, restoration fracture (bulk or margin), tooth fracture, and overhanging margin.[7,11-13]

New resin-based bonding materials and composite systems are regularly introduced for use in the esthetic restoration of posterior cavities.[6,10-13,27] These materials have two main characteristics: they are tooth colored and they can bond to tooth structure.[10,11,27] The use of resin-based composite materials became more popular as studies reported good durability when they were placed in small cavities under ideal conditions.[10-12]

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Adhesive bonding systems used to bond resin composites to dental tissue have developed rapidly over the past 30 years, beginning in the 1960s with the development of the first commercial products, followed by introduction of the acid-etch technique in clinical practice in the 1970s.[4,13,19] Since then, bonding systems have steadily become more refined and diversified. The current trend is to reduce the multistep adhesive process, so as to lessen the sensitivity to errors of inaccurate or incorrect operator handling.[21] Currently, many clinicians use one-bottle adhesive systems or self-etching/self-priming bonding systems.[21] Each type of adhesive bonding system has its advantages and limitations, but how these materials compare to each other in terms of pulp reaction is still uncertain.[13]

Long-term dental material bonding to dentin has been a contentious issue, and the results of in vitro testing do not reflect those found in vivo.[10,11,27] Although resin-based composite materials and adhesive technology have rapidly advanced, polymerizaton shrinkage and postoperative sensitivity still remain challenges to practitioners.[6,10,14,15,25,26] Clinical studies have also indicated that up to 30% of the studied populations have reported postoperative sensitivity following restoration with a posterior composite resin.[6,10,11,14,15,20,25-27]

The effect of immediate dentin sealing on the marginal adaptation and bond strengths of total-etch and self-etch adhesives

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Statement of problem. Sealing ability and bond strengths of total-etch and self-etch dentin adhesives used for immediate dentin sealing have not been assessed and established.

Purpose. The purpose of this study was to determine the effectiveness of immediate dentin sealing (IDS) using total-etch or self-etch dentin adhesives on microleakage and microtensile bond strength.

Material and methods. Twenty recently extracted molars were selected, and standard MOD inlay preparations were made with the gingival margins located below the cemento-enamel junction. The teeth were assigned to 4 experimental groups (n=5) according to the indirect composite restoration cementation technique used: (1) immediate dentin sealing with Adper Single Bond (TEBI); (2) conventional adhesive cementation technique using Adper Single Bond (TEAI); (3) immediate dentin sealing using Adper Prompt L-Pop (SEBI); or (4) conventional adhesive cementation technique using Adper Prompt L-Pop (SEAI). The restored teeth were thermal cycled 1,000 times between 5° and 55°C and then immersed in 50% ammoniacal silver nitrate. Three specimens per restoration were evaluated for microleakage, according to predefined scores, and submitted to Friedman's test (α=.05). The specimens were then sectioned to obtain 0.8 ±0.2-mm-thick sticks (with n ranging from 32 to 57 specimens) and submitted to microtensile bond strength (μTBS) testing. The obtained data were submitted to 2-way ANOVA test (α=.05).

Results. None of the experimental groups demonstrated complete elimination of marginal microleakage. There were significant differences in microleakage of the tested adhesives (P>.001). IDS microleakage scores were similar to those obtained using the conventional cementation technique (CCT) for both adhesives. The highest mean bond strengths were obtained with TEBI (51.1 MPa), whereas SEAI showed the lowest mean bond strengths (1.7 MPa). IDS resulted in significantly higher bond strengths than CCT (P<.001).

Conclusions. Total-etch and self-etch adhesives have a significant effect on IDS. IDS resulted in high bond strengths for both adhesives; however, the microleakage was similar to that obtained with CCT. (J Prosthet Dent 2009;102:1-9)

Clinical Implications

Despite immediate dentin sealing that resulted in high bond strengths for both adhesives, the marginal microleakage was not improved. The total-etch and self-etch adhesives evaluated have a significant effect on immediate dentin sealing.

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¿Son los adhesivos dentinarios una opción válida para el tratamiento de la sensibilidad cervical dentinaria?


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Are dentin bonding systems a valid option for the treatment of Cervical Dentin Sensitivity (C.D.S.)?

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Resumen: El objetivo de este trabajo es evaluar la capacidad *in vitro* de sellar túbulos dentinarios y reducir la permeabilidad dentinaria que tienen catorce productos propuestos para el tratamiento de la sensibilidad cervical dentinaria (SCD) y evaluar el efecto que la humedad y el cepillado tienen sobre ellos.
Material y método: 140 discos de dentina (obtenidos de 3º molares humanos recién extraídos) se dividen en catorce grupos de 10 discos que se montan en un sistema de perfusión basado en la máquina de Pashley que mantiene una presión positiva sobre las discos. Cada disco se graba con ácido ortofosfórico al 35% y su permeabilidad se mide en una hora, este valor se considera el de referencia (100%). Un disco queda como control y se aplica tratamiento a los otros 9, midiéndose su permeabilidad en una hora. Después se deja un disco como control, a los 8 restantes se les realiza un lavado y cepillado, viéndose su permeabilidad en una hora.
Resultados: Todos los productos afectaron a la perfusión dentinaria en mayor o menor grado. El cepillado de las muestras con el producto aplicado afectó a la permeabilidad, que en todas las preparaciones aumentó en mayor o menor grado. El mejor producto fue el Seal & Protect, seguido del Amm-i-dent + Xeno III, el Clearfil SE Bond y el Amm-i-dent + Scotchbond1.
Conclusiones: Todos los productos presentan mala resistencia al lavado y cepillado, lo que justifica el limitado éxito clínico de los agentes desensibilizantes. El que los cuatro mejores productos o combinaciones en cuanto a reducción de permeabilidad pertenezcan al grupo de los adhesivos dentinarios indica que estos pueden ser una alternativa válida para ser investigada y perfeccionada como tratamiento de la SCD.

Palabras clave: Sensibilidad dentinaria, Adhesivo dentinario, Permeabilidad Dentinaria

Abstract: The aim of this study is to evaluate the "in vitro" capability of fourteen agents proposed for the treatment of cervical dentin sensibility (CDS) to seal dentine tubules, to reduce dentine permeability and to resist the effect of wetness and tooth brushing.
Materials and Methods: 140 dentin discs were obtained from freshly extracted human third molars. Samples were divided into fourteen groups of 10 each and were mounted in a perfusion device based on the Pashley´s system. Each disc was etched with 35% phosphoric acid. Permeability was measured after 1 hour, this value was considered the reference value (100%). One disc was used as a control and nine were treated with a bonding system. Permeability was measured again after 1 hour. One disc was used as a control and 8 were washed with water and subjected to simulated tooth brushing equivalent to three weeks of normal brushing. Subsequebtly, permeability was measured again.
Results: All systems reduced dentinal perfusion when applied. Brushing of products produced an increase of permeability. The best results were obtained with Seal & Protect, follwed by Amm-i-dent + Xeno III, Clearfil SE Bond and Amm-i-dent+Scotchbond 1.
Conclusions: All products have shown low resistance to washing and brushing. This can justify unsatisfactory clinical results in reducing dentinal sensibility. The best four products were all adhesives or a combination of these, it seems to indicate that adhesives are a good choice to be investigated and improved for the treatment of CDS.

Key words: Dentin sensitivity, Bonding system, Dentin Permeability

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Evidence-based concepts and procedures for bonded inlays and onlays. Part II. Guidelines for cavity preparation and restoration fabrication

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Influence of immediate dentin sealing and temporary restoration on the bonding of CAD/CAM ceramic crown restoration

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This study examined the influences of clinical application of immediate dentin sealing (IDS) and temporary restoration (TR) on prepared abutment surfaces on the bonding of computer-aided design/computer-aided manufacturing (CAD/CAM) ceramic crown restorations after cyclic loading. Standardized abutments were prepared in 60 human mandibular premolars. Dentin surfaces of half of the specimens were sealed with adhesive and flowable composite, while those of the other half were not sealed. A half of both sealed and non-sealed specimens were restored using a temporary cement and temporary crown. Each individual CAD/CAM ceramic crown was fabricated and cemented to an individual abutment. The restored specimens were subjected to cyclic loading, and the micro tensile bond strengths (μ-TBS) were measured. IDS contributed to an increase in the bond strength, whereas TR did not affect the bond strength. IDS restoration without TR yielded the maximum bond reliability in achieve specific μ-TBS values for the restoration and ensuring durability against debonding.

Keywords: CAD/CAM restoration, Immediate dentin sealing, Temporary restoration, Microtensile bond strength, Weibull analysis

INTRODUCTION

Computer-aided design/computer-aided manufacturing (CAD/CAM) technology has recently begun to be employed in dental clinical practice. Conventional indirect restorations, such as cast gold restorations, require complex procedures. However, CAD/CAM restorations created using digital data taken from optical impressions can simplify these procedures. The latest CAD/CAM systems are especially capable of fabricating high-quality and uniform inlay/onlay/crown efficiently. Nevertheless, metal-free CAD/CAM restorations require robust adhesion between the tooth substance and the fabricated inlay/onlay/crown to obtain an excellent prognosis[1]. Immediate dentin sealing contributes to improved adhesion[2], enhanced adaptation[3], and the protection of the dentin pulp complex[4] in inlay/onlay restorations. However, the efficacy of immediate dentin sealing with adhesive systems and flowable resin composites on metal-free CAD/CAM crown restorations has not been examined. Metal-free crown restorations for vital teeth may cause pulp damage, *i.e.*, inflammation and necrosis, because of the substantial reduction in tooth substance as a result of the abutment preparation process[5]. Therefore, establishment of an application method for immediate dentin sealing of metal-free crown restorations should provide benefits in clinical practice.

Chair-side CAD/CAM systems allow one-day treatment[6,7]. In contrast, laboratory CAD/CAM restorations that are fabricated in the laboratory using digital data obtained with an intraoral scanner at the clinical office are worldwide[8]. However, the laboratory service requires multiple patient visits, similar to the conventional indirect restoration. The use of temporary restorations using temporary crowns and cement is necessary for the abutment tooth during crown restoration over multiple visits. Thus, determination of the influences of one-day treatment without temporary restoration and laboratory CAD/CAM restoration with temporary restorations on the bonding of CAD/CAM restorations is significant for the clinical application of these two restoration approaches. In this context, immediate dentin sealing has also been reported to ameliorate the reduction in bond strength caused by the application of temporary cement[9,10]. However, there is no report that evaluate the influence of the immediate dentin sealing and temporary cement on bonding under condition which mimicked intraoral environment.

Measurement of bond strength is a method for evaluating adhesive restorations. The microtensile bond strength (μ-TBS) test introduced by Sano *et al.*[11] is a useful method for investigating internal bond strength that is influenced by various intraoral stresses, such as thermal and cyclic load stress[12]. In this regard, the International Organization for Standardization (ISO) technical specification 11405 guidelines state[13] that calculations of the probability of failure using the Weibull distribution function are a suitable approach for comparing many materials[14].

This study aimed to examine the differences in bonding behavior among CAD/CAM ceramic restorations with and without immediate dentin sealing and temporary restorations after cyclic loading, simulating the intraoral condition, by measurement of μ-TBS values, investigation of the bond reliability and durability, and observation of the failure mode. The null hypotheses of this study were as follows: 1) immediate dentin sealing did not improve the bonding of CAD/CAM ceramic crown restorations; 2) temporary restorations did not have a negative influence on the bonding of CAD/

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Effect of Resin Coating on Adhesion of Composite Crown Restoration

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The purpose of this study was to evaluate the effect of a resin coating technique on the microtensile bond strength (μTBS) of resin cement to dentin in composite crown restorations. Crown preparations were done on human molars. A resin coating material, Hybrid Bond, was immediately applied to the prepared dentin and light-cured, while the tooth without resin coating acted as the control. An impression of the resin-coated tooth was taken, and a composite crown fabricated on the working cast. The composite crown was then bonded with a resin cement, Chemiace II. μTBSs were measured at a cross-head speed of 1 mm/min, and the resin-coated group yielded significantly higher μTBSs than the non-coated group ($p<0.05$). In terms of μTBS values between the axial and occlusal surfaces, no regional differences in resin-dentin bond strength were detected ($p<0.05$). It was concluded that resin coating with Hybrid Bond significantly improved the μTBS of resin cement to dentin in composite crown restorations.

Key words: Resin coating, Indirect restoration, Resin cement

INTRODUCTION

Resin cements have been widely advocated for luting indirect tooth-colored restorations. However, current resin cements do not always provide good bonding to dentin compared with the dentin bonding systems for direct composite restorations[1,2]. In the early 90s, a resin coating technique was introduced for indirect restorations to minimize pulpal irritation and postoperative sensitivity[3]. This technique also enables better bonding, sealing, and adaptation to dentin[4,5]. These benefits then help to prevent contamination of the prepared dentin surfaces with temporary filling materials, blood, and saliva − which are clinical factors that could reduce the dentin bonding capacity of resin cements[6].

Resin coating in combination with a dentin adhesive system and a low-viscosity microfilled resin has been recommended for the prepared cavity immediately after tooth preparation, just before taking the impression. This technique produces a hybrid layer and a tight sealing film on the dentin surface[7−10]. However, the combination of a dentin bonding system and a low-viscosity microfilled resin creates a layer of more than 100 μm thickness on the dentin surface[8], which is too thick[8] for coating of crown preparations.

Recently, a thin-film coating material has been developed through the technology of single-step bonding systems[11]. It was reported that the thin-film coating material could prevent marginal leakage beneath full cast crowns[12]. However, there is little information on the dentin bonding performance of resin coating materials on teeth prepared for crowns.

Therefore, the purpose of this study was to evaluate the microtensile bond strength of resin cement to resin-coated dentin using a single-step coating material on teeth prepared for indirect composite crowns. In addition, the ultrastructure of the interface between the resin cement and dentin was examined by a scanning electron microscope (SEM). The null hypothesis of this study was that the resin coating material did not influence the bonding performance of composite crown restorations.

MATERIALS AND METHODS

Specimen preparation

Preparation methods of both resin-coated and non-coated samples for microtensile bond strength (μTBS) testing is illustrated in Fig. 1. Twenty-eight extracted, non-carious, human lower first molars, stored in normal saline at 4℃, were used in this study. Each tooth was prepared for a full veneer crown with slightly rounded internal line angles using a superfine diamond bur (SF 145, Shofu Co., Kyoto, Japan) mounted on a high-speed handpiece under water coolant. Dentin margin of the crown preparations was situated below the cementoenamel junction. Prepared tooth surfaces were also exam-

A Critical Review of the Durability of Adhesion to Tooth Tissue: Methods and Results

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ABSTRACT

The immediate bonding effectiveness of contemporary adhesives is quite favorable, regardless of the approach used. In the long term, the bonding effectiveness of some adhesives drops dramatically, whereas the bond strengths of other adhesives are more stable. This review examines the fundamental processes that cause the adhesion of biomaterials to enamel and dentin to degrade with time. Non-carious class V clinical trials remain the ultimate test method for the assessment of bonding effectiveness, but in addition to being high-cost, they are time- and labor-consuming, and they provide little information on the true cause of clinical failure. Therefore, several laboratory protocols were developed to predict bond durability. This paper critically appraises methodologies that focus on chemical degradation patterns of hydrolysis and elution of interface components, as well as mechanically oriented test set-ups, such as fatigue and fracture toughness measurements. A correlation of *in vitro* and *in vivo* data revealed that, currently, the most validated method to assess adhesion durability involves aging of micro-specimens of biomaterials bonded to either enamel or dentin. After about 3 months, all classes of adhesives exhibited mechanical and morphological evidence of degradation that resembles *in vivo* aging effects. A comparison of contemporary adhesives revealed that the three-step etch-and-rinse adhesives remain the 'gold standard' in terms of durability. Any kind of simplification in the clinical application procedure results in loss of bonding effectiveness. Only the two-step self-etch adhesives approach the gold standard and do have some additional clinical benefits.

KEY WORDS: artificial aging, dental adhesives, enamel, dentin.

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(1) INTRODUCTION

The major shortcoming of contemporary adhesive restoratives is their limited durability *in vivo* (Van Meerbeek *et al.*, 1998). The most cited reasons for failure of adhesive restorations are loss of retention and marginal adaptation (Mjör *et al.*, 2002; Mjör and Gordan, 2002). Hence, a valuable approach to prolong the clinical lifetime of adhesives might be to focus on improving the stability of the bond of these biomaterials to tooth tissue. The immediate bonding effectiveness of most current adhesive systems is quite favorable (Inoue *et al.*, 2001b), regardless of the adhesive used. However, when these adhesives are tested in a clinical trial, the bonding effectiveness of some materials appears dramatically low, whereas the bonds of other materials are more stable (Van Dijken, 2000; Brackett WW *et al.*, 2002). The objective of this review is to discuss the potential *in vivo* degradation processes involved, to critically review study designs to assess these phenomena, and, eventually, to find out how well laboratory tests can predict *in vivo* bond durability.

(2) CLASSIFICATION OF CONTEMPORARY ADHESIVES

The basic mechanism of bonding to enamel and dentin is essentially an exchange process involving replacement of minerals removed from the hard dental tissue by resin monomers, which, upon setting, become micro-mechanically interlocked in the created porosities. This interlock was first described by Nakabayashi *et al.* in 1982 and is commonly referred to as 'hybridization', or the formation of a 'hybrid layer'. Based upon the underlying adhesion strategy, three mechanisms of adhesion are currently in use with modern adhesive systems (Fig. 1; Van Meerbeek *et al.*, 2001, 2003).

(2.1) Etch-and-Rinse Adhesives

'Etch-and-rinse' adhesives involve a separate etch-and-rinse phase. In their most common configuration, an acid (mostly 30-40% phosphoric acid) is applied and rinsed off. This conditioning step is followed by a priming step and application of the adhesive resin, resulting in a three-step application procedure. Simplified two-step etch-and-rinse adhesives combine the primer and adhesive resin into one application.

(2.2) Self-etch Adhesives

An alternative approach is based on the use of non-rinse acidic monomers that simultaneously condition and prime dentin, the so-called 'self-etch' adhesives. Regarding user-friendliness and technique-sensitivity, this approach seems clinically most promising. This approach eliminates the rinsing phase, which not only lessens the clinical application time, but also significantly reduces the technique-sensitivity or the risk of making errors during application. There are basically two types of 'self-etch' adhesives: 'mild' and 'strong' (Van Meerbeek *et al.*, 2001). 'Strong' self-etch adhesives have a very low pH (< 1) and exhibit a bonding mechanism and interfacial ultra-morphology in dentin resembling that produced by etch-and-rinse adhesives. 'Mild' self-etch adhesives (pH of around 2) dissolve the dentin surface only

Efficacy of a Resin Coating on Bond Strengths of Resin Cement to Dentin

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ABSTRACT

Purpose: The aims of this study were to (1) evaluate the effect of a resin coating consisting of a dentin bonding system and a flowable resin composite on the microtensile bond strength (μ-TBS) of a resin cement to dentin in indirect composite restorations and (2) compare the bond strengths of direct and indirect composite restorations.

Materials and Method: Occlusal surfaces of human premolars were ground to obtain flat dentin surfaces and were divided into seven groups. For indirect restorations, the dentin surfaces of the experimental groups were bonded with a dentin bonding system (DBS), Clearfil SE Bond (SE) or Single Bond (SB) with and without a flowable resin composite, Protect Liner F (PLF), temporized for one day and cemented with a resin cement (Panavia F) according to the manufacturer's instructions. The dentin surfaces of the control group were temporized without prior treatment, and indirect composite (Estenia) was bonded with Panavia F. For the direct restorations, either SE or SB was applied to the dentin surface and the entire surface was built up with direct composite (Clearfil AP-X). After 24 hours in water storage, μ-TBS was measured at a crosshead speed of 1 mm/min. The data were analyzed with one-way analysis of variance and Fisher's protected least significant difference test ($p < .05$).

Results: The original bond strength of the resin cement (Panavia F) to dentin significantly improved with the use of a resin coating technique in indirect restorations ($p < .05$). The combination of DBS + PLF showed significantly higher bond strengths compared with the single use of DBS. The combination of SE + PLF as a resin coating provided the highest bond strengths in indirect restorations ($p < .05$). However, the best bond strengths were observed when SE and SB were used for direct composite restorations ($p < .05$).

Conclusions: The application of a resin coating consisting of a dentin bonding system and a flowable resin composite on the dentin following cavity preparation significantly improved the μ-TBS of the resin cement Panavia F to dentin in indirect restorations. However, the bond strengths of indirect composite restorations were significantly lower than those of direct composite restorations even with the resin coating technique.

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The effect of a resin-based sealer on crown retention for three types of cement

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Statement of problem. In an effort to control postoperative sensitivity, dentin sealers are being applied following crown preparation with little knowledge of how crown retention might be affected. A previous study demonstrated no adverse effect when using a glutaraldehyde-based sealer, and existing studies have shown conflicting results for resin-based products.

Purpose. This study determined if a resin sealer applied to prepared dentin affected retention of cemented castings when using 3 common types of luting agents.

Material and methods. Extracted human molars (n=55) were prepared with a flat occlusal, 20-degree taper, and 4-mm axial length. The axial surface area of each preparation was determined and specimens were distributed equally among groups (n=11). A 2-step, single-bottle adhesive system (One Step) was used to seal dentin following tooth preparation. Sealer was not used on the control specimens except for the modified-resin cement (Resinomer) specimens that required use of adhesive with cementation. Using ceramometal high noble alloy (Olympia), a casting was produced for each specimen and cemented with a seating force of 20 Kg using either zinc phosphate (Fleck's), glass ionomer (Ketac-Cem) or modified-resin cement (Resinomer) with the single-bottle adhesive. Castings were thermal cycled at 5°C and 55°C for 2500 cycles; then removed along the path of insertion using a universal testing machine at 0.5 mm/min. A single-factor ANOVA was used with α=.05. The nature of failure was also recorded and the data analyzed with a chi-square test.

Results. Mean dislodgment stresses for unsealed and sealed conditions were 3.7 ± 1.0 and 2.2 ± 0.8 MPa for zinc phosphate; 2.7 ± 1.2 and 4.2 ± 0.9 MPa for glass ionomer, respectively (P<.001). Retentive stress of castings cemented with modified-resin cement was 6.4 ± 1.7 MPa. With resin sealer in combination with zinc phosphate, cement resided totally on castings in 82% of the situations and was on both surfaces without sealer. The tooth failed before casting dislodgent in 9 of 11 specimens cemented with modified-resin cement.

Conclusions. Resin sealer decreased casting retentive stress by 42% when used with zinc phosphate. However, sealer use resulted in 55% increased retention when used with glass ionomer. The modified-resin cement produced the highest mean dislodgment stress, nearly always exceeding the strength of the tooth. (J Prosthet Dent 2004;91:428-35.)

CLINICAL IMPLICATIONS

This in vitro study suggests that a resin-based sealer is not indicated after tooth preparation when crowns are to be luted with zinc phosphate cement because of decreased crown retention stress, probably attributed to reduced roughness of prepared dentin. Resin sealer may be used successfully with glass ionomer and modified-resin cements tested. Given short clinical crowns or a high angle of convergence, the modified-resin cement system may retain castings best.

Dentin reduction and exposure of prepared tooth surface can lead to increased dentin permeability[1-3] and subsequent pulpal irritation. Several agents have been advocated for sealing dentin prior to cementation of cast restorations to decrease post-cementation sensitivity.[4,5] A clinical study demonstrated control of sensitivity with a glutaraldehyde-base dentin bonding system.[6] A subsequent study[7] used Allbond 2 and Optibond adhesives in combination with the glutaraldehyde-based sealer and reported no effect of the sealer on composite shear strength for either adhesive. Given concern for adverse effects of resin-based sealers on casting retention, a study evaluated 2 different resin bonding systems as desensitizing agents. That study showed a reduction in retention for zinc phosphate and polycarboxylate cements when Allbond 2 was used, and glass ionomer cement was adversely affected by Imperva bonding

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Bonding effectiveness of adhesive luting agents to enamel and dentin

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ABSTRACT

Objectives. The bonding effectiveness of five adhesive luting agents to enamel and dentin using different application procedures was determined using a micro-tensile bond strength protocol (μTBS).

Methods. Enamel/dentin surfaces of human third molars were flattened using a high-speed diamond bur. Composite resin blocks (Paradigm, 3 M ESPE) were luted using either Linkmax (LM; GC), Nexus 2 (NX; Kerr), Panavia F (PN; Kuraray), RelyX Unicem (UN; 3M ESPE) or Variolink II (VL; Ivoclar-Vivadent), strictly following manufacturers' instructions. For some luting agents, modified application procedures were also tested, resulting in four other experimental groups: Prompt L-Pop + RelyX Unicem (PLP + UN; 3 M ESPE), Scotchbond Etchant + RelyX Unicem (SE + UN; 3 M ESPE), Optibond Solo Plus Activator + Nexus 2 (ACT + NX; Kerr) and K-Etchant gel + Panavia-F (KE + P; Kuraray). The experimental groups were classified according to the adhesive approach in self-adhesive (UN), etch-and-rinse (ACT + NX, NX, KE + P, SE + UN and VL when bonded to enamel) and self-etch adhesive luting agents (LM, PLP + UN, PN and VL when bonded to dentin). The specimens were stored for 24 h in distilled water at 37 °C prior to μTBS testing. The Kruskal–Wallis test was used to determine pairwise statistical differences ($p < 0.05$) in μTBS between the experimental groups.

Results. When bonded to enamel, ACT + NX (15 MPa) and UN (19.6 MPa) scored significantly lower than VL (49.3 MPa), LM (49.2 MPa), PN (35.4 MPa) and SE + UN (35.2 MPa), while PLP + UN (23.5 MPa) showed a significantly lower μTBS than VL (49.3 MPa) and LM (49.2 MPa). No significant differences were noticed between VL (49.3 MPa), LM (49.2 MPa), NX (37.9 MPa), KE + PN (38.8 MPa), PN (35.4 MPa) and SE + UN (35.2 MPa). Regarding the bonding effectiveness to dentin, all luting agents bonded equally effectively (UN: 15.9 MPa; LM: 15.4 MPa; PN: 17.5 MPa; NX: 22.3 MPa), except VL (1.1 MPa), SE + UN (5.9 MPa) and ACT + NX (13.2 MPa). VL revealed an exceptionally high number of pre-testing failures, most likely due to a combined effect of not having cured the adhesive separately and an insufficiently light-cured luting agent.

Significance. Following a correct application procedure, the etch-and-rinse, self-etch and self-adhesive luting agents are equally effective in bonding to enamel and dentin. Several factors

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Original Article

Microtensile Bond Strength of Indirect Resin Composite to Resin-coated Dentin: Interaction between Diamond Bur Roughness and Coating Material

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Abstract

This aim of this study was to determine the effect of type of bur and resin-coating material on microtensile bond strength (μTBS) of indirect composite to dentin. Dentin surfaces were first ground with two types of diamond bur and resin-coated using UniFil Bond (UB) or Adper Single Bond (SB), and then bonded to a resin composite disc for indirect restoration with adhesive resin cement. After storage for 24 hr in distilled water at 37°C, μTBS was measured (crosshead speed 1 mm/min). When UB was applied to dentin prepared using the regular-grit diamond bur, μTBS was significantly lower than that in dentin prepared using the superfine-grit bur. In contrast, no significant difference was found between regular-grit and superfine-grit bur with SB. However, more than half of the superfine-grit specimens failed before μTBS testing. These results indicate that selection of bur type is important in improving the bond strength of adhesive resin cement between indirect resin composite and resin-coated dentin.

Key words: Diamond bur roughness—Resin coating—Microtensile bond strength—Indirect composite restoration

Introduction

To achieve a prepared cavity surface with a hybrid layer and tight sealing film, a resin-coating technique was proposed for indirect restorations in the early 1990's which employed an adhesive system and low-viscosity resin composite[18,24]. This technique has recently been shown to be capable of not only increasing the bond strength of resin cement and producing good interfacial adaptation[7,8,10,17], but also protecting the prepared dentin

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Artículo Original

Resistencia adhesiva dentina-resina utilizando tres sistemas adhesivos a diferentes tiempos de aplicación. Estudio *in vitro*

Resin dentin bond´s resistance using three adhesive systems at different application times. Study *in vitro*

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Resumen

Objetivo. Evaluar la resistencia adhesiva dentina-resina (RADR) en adhesivos *Optibond FL* (OFL), *Adper Single Bond 2* (ASB2) y *Single Bond Universal* (SBU) en tres tiempos diferentes de aplicación. **Métodos.** Estudio experimental *in vitro*, se empleó nueve molares humanas obteniéndose, 135 especímenes de 1 mm^2 aproximadamente conformando nueve grupos de estudio de 15 especímenes para cada grupo. La RADR se midió a través del test de microtensión a una fuerza de tracción con una aceleración de 0,5 mm/min hasta la fractura. El contraste de hipótesis de diferencia se realizó utilizando el test de ANOVA de un factor y comparaciones múltiples de Tukey, ambos a un nivel de confianza del 95%. **Resultados.** A los 10 segundos, se hallaron diferencias significativas entre los sistemas adhesivos OFL (25,78 ± 5,98 MPa) vs ASB2 (de 14,02 ± 3,06 MPa), p<0,001, así como entre OFL vs SBU (14,36 ± 4,69 MPa) con p<0,001**.** A los 20 segundos, entre OFL (34,37 ± 6,03 MPa) y ASB2 (16,33 ± 3,02 MPa), p<0,001, así como entre OFL y SBU (19,44 ± 5,98 MPa) con p<0,001. A los 30 segundos también se encontraron las mismas diferencias entre OFL (37,6 ± 11,93 MPa) y ASB2 (16,62 ± 1,81 MPa), p<0,001, así como entre OFL y SBU (23,56 ± 7,3 MPa) p<0,001. **Conclusiones.** *Optibond FL* presentó mayor RADR frente a ASB2 y SBU en los tres tiempos; entre ASB2 y SBU a 10 s no se encontró diferencia, a los 20 s y 30 s SBU presentó mayor RADR. En los tres grupos hubo aumento significativo de la RADR entre los 10 y 30 segundos.

Palabras clave: Dentina; Adhesión dental; Adhesivos (fuente: DeCS BIREME).

Abstract

Objective. To evaluate the dentin-resin bond´s resistance (DRBR) of the adhesives Optibond FL (OFL), Adper Single Bond 2 (ASB2) and Single Bond Universal (SBU) with its self-engraving possibility, in three different times of application. **Methods.** Experimental, comparative and crossectional in vitro study. We used nine human molars, obtaining 135 specimens of 1 mm^2 approximately, forming nine study groups of 15 specimens for each group. The DRBR was measured through the Microtunsion test at a tensile force with an acceleration of 0.5mm/min until a fracture.The contrast of difference hypotheses was performed using the one-factor ANOVA test and Tukey's multiple comparisons, both at

Effect of Resin-Coating Technique on Dentin Tensile Bond Strengths over 3 Years

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ABSTRACT

Purpose: The resin-coating technique has been developed to protect prepared dentin and underlying pulp tissue. The purpose of this study was to evaluate the resin-coated dentin bond durability over a period of 3 years of a resin cement and to compare it with two representative resin cements.

Materials and Methods: Ten bovine dentin specimens were tested for tensile bond strengths with each of the following three materials: CLAPEARL DC with a resin-coating technique (CDRC), Panavia 21 (PA21), and Super Bond C&B (SBCB) at 1 day, 6 months, 1 year, and 3 years. Mean bond strengths were compared statistically by two-way analysis of variance and Fisher's PLSD test ($p < .05$). The mode of failure was classified by scanning electron microscope observation and analyzed using the Mann-Whitney U-test.

Results: The 3-year bond strengths of all resin cements were significantly lower than those at the other experimental periods except for 1 year ($p < .05$). There was no significant difference in mean bond strength between CDRC and SBCB ($p > .05$). Regarding the fracture modes, in the case of CDRC, an increase in adhesive failure at the resin–dentin interface was observed as the time period lengthened. Statistical differences were observed between SBCB and the other materials at 1 year ($p < .05$) and between PA21 and the other materials at 3 years ($p < .05$).

CLINICAL SIGNIFICANCE

The mean tensile bond strengths of the three resin cements to dentin decreased at different rates during the study; the rate at which the bond decreases is likely to affect the long-term durability of restorations.

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Indirect and direct resin composite restorations are being used more widely as esthetic restorations. The most recent formulation of resin composite materials is superior to earlier versions with regard to strength, wear resistance, and color stability.[1,2] However, the main shortcoming of resin composite as a direct restorative material is polymerization shrinkage.[2–4] The stresses produced during polymerization can cause adhesive or cohesive failure within the bonding layer and interfacial gap formation. Sev-

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Effect of Resin Coating as a Means of Preventing Marginal Leakage beneath Full Cast Crowns

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The purpose of this study was to evaluate the effectiveness of resin coating as a means of preventing marginal leakage beneath full cast crowns which were emplaced using different cements. Standard full cast crown preparation was made on 64 extracted premolars. These samples were then divided into four groups, with half of each group coated with dentin coating material after preparation. Crowns were cemented onto the teeth using zinc cement, Fuji I, Vitremer, or C&B Metabond. The samples were thermal-cycled for 10,000 cycles. They were then immersed in erythrosine solution, sectioned, and observed under a microscope. Microleakage analyses were performed using a 0-4 point system. The data were statistically analyzed. There were significant differences between the coated specimens and the uncoated specimens using Fuji I and Vitremer.

The results showed that a resin coating could decrease the amount of marginal leakage when applied with these two cements.

Key words: Resin coating, Luting materials, Microleakage

INTRODUCTION

After an abutment is prepared, the exposed dentin may be contaminated by oral fluids by the time the restoration has been finally cemented in place[1,2]. Contamination can cause bacterial infection of the dental pulp via the dentinal tubules, frequently leading to much discomfort for the patient in the form of spontaneous pain and tooth sensitivity[2−8]. Hyperesthesia is often caused by inflammatory reaction of the pulp due to stimulation during preparation or bacterial infection of the pulp through exposed dentinal tubules after preparation[3,4]. An attempt is being made to prevent bacterial infection of the pulp due to bacteria or products created by bacteria entering through the dentinal tubules, by sealing exposed dentinal tubules using a bonding agent[1,9−15]. It is known that a resin coating provides protection of the dental pulp for a period until the restoration is cemented[9−16]. Resin coating may serve to protect the pulp, improve the resin cement's bond to the tooth, and reduce the gap between the restoration and the cavity wall[10,12,13]. However, the effectiveness of resin coating as a means of preventing marginal leakage beneath full cast crowns has hardly been discussed. Thus, it is not clear whether resin coating is effective or not over a long period in the oral cavity, where a variety of stresses such as temperature change are experienced.

In this study, preparations for full cast crown were made, restorations were mounted, and then, the specimens were thermal-cycled 10,000 times to evaluate the ability of the resin coating to seal dentinal tubules.

MATERIALS AND METHODS

Sixty-four extracted, sound human maxillary and mandibular premolars were used for the experiment. After extraction, they were kept in normal saline water at 3℃. The tooth root was scaled before the experiment. Standard dentin-bonded type abutments were prepared. The preparation was accomplished using diamond burs (Smooth Cut BR2 ISO No. 198016/GC, Tokyo, Japan) with a high-speed, air-turbine handpiece (Kavo, Biberach, Germany) and a constant water spray as a coolant. The following points were taken into consideration: (1) removing all enamel from the abutment; (2) making a taper of 6° on the abutment; (3) giving a chamfer-edge finish at the cervical area, with a margin created in dentin.

The prepared teeth were then randomly divided into four major groups (n=16), and each major group was further divided into two subgroups (n=8). One subgroup of each of the major groups was coated with an experimental dentin coating material (code name RZ II − now commercially available as Brush and Bond, Parkell, Farmingdale, NY, USA). RZ II was a single-step, non-rinsing, self-etching adhesive[11]. The RZ II kit consisted of a sponge and a liquid component. The liquid component contained water, acetone, 4-META, acrylic monomer, photoinitiator, and stabilizer. The sponge contained p-toluenesulfinate salt, and amine as a catalyst[17,18]. The groups coated with RZ II had the

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Effect of Immediate Dentin Sealing in Prevention of Post-Cementation Hypersensitivity in Fullcoverage Restorations

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Abstract:
Aim: *The aim of this study is to investigate the effect of immediate dentin sealing with dentin bonding agent on preventing post-cementation hypersensitivity in vital abutment teeth restored with a full-coverage restoration.* ***Method:*** *A total of 50 patients were enrolled in this study who received three unit fixed dental prosthesis on vital abutments in mandibular posterior region, 25 each in the age ranges of 21-30 and 31-40 years. Sixth generation bonding agent was applied after tooth preparation and before impression making. Final prosthesis was luted using GlassIonomer luting cement. The sensitivity assessment was done after 1 week, 1 month and 6 months.* ***Results****: There was statistically significant difference in the reduction of sensitivity with the use of a dentin bonding agent at 1 week and 1 month but not at 6 months. There was no significant difference between the age groups.*
Conclusion*: Preventive treatment with immediate dentin sealing using a dentin bonding agent significantly reduces immediate post-cementation hypersensitivity.*
Keywords: *Post-cementation hypersensitivity; Luting cement; Dentin bonding agent.*

I. Introduction

Fixed prosthodontic treatment involves the replacement and restoration of teeth by artificial substitutes that are not readily removable from the mouth by the patient and serve to restore function, esthetics and comfort. The tooth preparation for metal ceramic fixed dental prosthesis requires significant amount of tooth structure reduction; however, in most cases pulp vitality of the abutments can be maintained by protecting the tooth preparation with provisional fixed prosthesis luted with temporary luting cement, which is an essential and key step in successful fixed prosthodontic treatment.

Post-cementation hypersensitivity is a symptom characterized by a short, sharp pain when contacting thermal and chemical stimuli to the vital abutment teeth after permanent cementation of the restoration. In spite of following a standard protocol, some patients suffer from hypersensitivity following cementation of restorations on teeth. According to the survey by Rosenstiel and Rashid, the incidence of post-cementation hypersensitivity is about 10%.[1]Increased sensitivity to hot or cold stimulation is an occasional, but perplexing, unwanted consequence of a newly cemented crown or fixed partial denture.[2]

There are many factors considered to be associated with the occurrence of post-cementation hypersensitivity such as overheating and desiccation during tooth preparation[3], infiltration of bacteria that were either left behind or gained access to the dentin due to microleakage[4] and the amount of tooth reduction[5]. Glass Ionomer luting cement which is one of the most commonly used permanent luting agents for cast restorations has a comparatively low initial setting pH at the time of placement and this has been implicated as a cause of post-cementation sensitivity[6] when the prosthesis is being cemented on vital teeth.

Immediate dentin sealing (IDS) is a new approach in which the dentin is sealed immediately after tooth preparation and prior to impression making. A clean dentin surface is mandatory for optimal seal and adhesion. Freshly cut dentin is uncontaminated and clean, thus more easily capable of resin infiltration. Immediate sealing of dentin protects it from contamination from bacterial leakage or remnants of temporary cements.[7]Capturing the hybrid layer into the impression will eliminate the concern for gap formation and ill-fitting restorations.

II. Materials and Methods

A total of 50 patients were enrolled in this study who received three unit fixed dental prosthesis on vital abutments in mandibular posterior region. They were divided into two groups of 25 each. Group A consisting of 25 patients in the age group of 21-30 years or younger group and Group B consisting of 25 patients in the age group of 31-40 years or middle aged group. Treatment was carried out with the patients' informed consent. All patients received detailed particulars (verbal and written) on the course of treatment and the purpose of the study. The patients were included in the study only after obtaining a signed consent form.A Double Blind

The effect of IDS (immediate dentin sealing) on dentin bond strength under various thermocycling periods

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PURPOSE. The purpose of this study was to find out the effect of immediate dentin sealing (IDS) on bond strength of ceramic restoration under various thermocycling periods with DBA (dentin bonding agent system). **MATERIALS AND METHODS**. Fifty freshly extracted human mandibular third molars were divided into 5 groups (1 control and 4 experimental groups) of 10 teeth. We removed enamel layer of sound teeth and embedded them which will proceed to be IDS, using All Bond II. A thermocycling was applied to experimental groups for 1, 2, 7, 14 days respectively and was not applied to control group. IPS Empress II for ceramic was acid-etched with ceramic etchant (9.5% HF) and silane was applied. Each ceramic disc was bonded to specimens with Duo-link, dual curable resin cement by means of light curing for 100 seconds. After the cementation procedures, shear bond strength measurement and SEM analysis of the fractured surface were done**.** The data were analyzed with a one-way ANOVA and Tukey multiple comparison test (α=.05). **RESULTS**. There were no statistically significant differences between 4 experimental groups and control group, however the mean value started to decrease in group 7d, and group 14d showed the lowest mean bond strength in all groups. Also, group 7d and 14d showed distinct exposed dentin and collapsed hybrid layer was observed in SEM analysis. **CONCLUSION**. In the present study, it can be concluded that ceramic restorations like a laminate veneer restoration should be bonded using resin cement within one week after IDS procedure. ***[J Adv Prosthodont 2015;7:224-32]***

KEY WORDS: Immediate dentin sealing; SEM analysis; Dentin bonding; Thermocycling; Ceramic restoration

INTRODUCTION

Patient expect for improved esthetics has driven the advancement of ceramic for use with fixed partial prostheses.[1]

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Many clinical studies demonstrate excellent long-term success of ceramic restorations. In recent year, strong ceramic cores unioning esthetic veneering porcelains have become popular as all ceramic restorations which have compensated the brittleness of porcelain and unesthetic metal substructure. The clinical success of all ceramic prosthesis depends on a number of factors, such as composition of the ceramic material and the cementation procedure.[2] Hence, bonding to ceramic requires strict attention to detail for optimal clinical outcomes.[3]

A vital importance is due to the adhesive strength and durability of the complex formed between the three different components: the resin cement, the ceramic surface and the tooth surface especially in anterior laminate veneers.[4,5] In some cases, significant amounts of exposed dentin is usually unavoidable during the preparation of anterior teeth,[1,6] the protection is required during the period between preparation and cementation for prevention of post-opera-

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Immediate Dentin Sealing of Onlay Preparations: Thickness of Pre-cured Dentin Bonding Agent and Effect of Surface Cleaning

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Clinical Relevance

The film thickness of the DBA used for the "immediate dentin sealing" of onlay preparations prior to final impression, making for indirect restorations, presents a vast range of values, depending on both the type of DBA and the topography of the tooth preparation. Curing the DBA in the absence of oxygen (air blocking) is mandatory to maintain a minimum DBA thickness. The filled DBA presented a more uniform thickness compared to the unfilled one. Air abrasion and polishing used for cleaning the pre-cured DBA prior to final cementation reduces the thickness of the DBA in a non-uniform manner.

SUMMARY

This study evaluated the thickness of Dentin Bonding Agent (DBA) used for "immediate dentin sealing" of onlay preparations prior to final impression making for indirect restorations. In addition, the amount of DBA that is removed when the adhesive surface is cleaned with polishing or air abrasion prior to final cementation was evaluated. For this purpose, a standardized onlay preparation was prepared in 12 extracted molars, and either OptiBond FL (Kerr) or Syntac Classic (Vivadent) was applied to half of the teeth and cured in the absence of oxygen (air blocking). Each tooth was bisected in a bucco-lingual direction into two sections, and the thickness of the DBA was measured under SEM on gold sputtered epoxy resin replicas at 11 positions. The DBA layer of each half tooth was treated with either air abrasion or polishing. The thickness of the DBAs was then re-measured on the replicas at the same positions. The results were statistically analyzed with non-parametric statistics (Mann-Whitney U test and Kruskal-Wallis test) at a confidence level of 95% (*p*=0.05).

The film thickness of the DBA was not uniform across the adhesive interface (121.13 ± 107.64 µm), and a great range of values was recorded (0 to 500 µm). Statistically significant differences (*p*<0.05) were noted, which were both material (OptiBond FL or Syntac Classic) and position (1 to 11) dependent. Syntac Classic presented a higher thickness of DBA (142.34 ± 125.10 µm) than OptiBond FL (87.99 ± 73.76 µm). The higher film thickness of both DBAs was at the deepest part of the isthmus (the most concave part of the preparation), while the lowest was at the line angles of

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Immediate dentin sealing improves bond strength of indirect restorations

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Statement of problem. Delayed dentin sealing is traditionally performed with indirect restorations. With this technique, dentin is sealed after the provisional phase at the cementation appointment. It was demonstrated that this chronology does not provide optimal conditions for bonding procedures. Immediate dentin sealing (IDS) is a new approach in which dentin is sealed immediately following tooth preparation, before making the impression.

Purpose. The purpose of this study was to determine whether there were differences in microtensile bond strength to human dentin using IDS technique compared to delayed dentin sealing (DDS).

Material and methods. Fifteen freshly extracted human molars were obtained and divided into 3 groups of 5 teeth. A 3-step etch-and-rinse dentin bonding agent (DBA) (OptiBond FL) was used for all groups. The control (C) specimens were prepared using a direct immediate bonding technique. The DDS specimens were prepared using an indirect approach with DDS. Preparation of the IDS specimens also used an indirect approach with IDS immediately following preparation. All teeth were prepared for a nontrimming microtensile bond strength test. Specimens were stored in water for 24 hours. Eleven beams (0.9 × 0.9 × 11 mm) from each tooth were selected for testing. Bond strength data (MPa) were analyzed with a Kruskal-Wallis test, and post hoc comparison was done using the Mann-Whitney U test (α=.05). Specimens were also evaluated for mode of fracture using scanning electron microscope (SEM) analysis.

Results. The mean microtensile bond strengths of C and IDS groups were not statistically different from one another at 55.06 and 58.25 MPa, respectively. The bond strength for DDS specimens, at 11.58 MPa, was statistically different (P=.0081) from the other 2 groups. Microscopic evaluation of failure modes indicated that most failures in the DDS group were interfacial, whereas failures in the C and IDS groups were both cohesive and interfacial. SEM analysis indicated that for C and IDS specimens, failure was mixed within the adhesive and cohesively failed dentin. For DDS specimens, failure was generally at the top of the hybrid layer in the adhesive. SEM analysis of intact slabs demonstrated a well-organized hybrid layer 3 to 5 μm thick for the C and IDS groups. For DDS specimens the hybrid layer presented a marked disruption with the overlying resin.

Conclusions. When preparing teeth for indirect bonded restorations, IDS with a 3-step etch-and-rinse filled DBA, prior to impression making, results in improved microtensile bond strength compared to DDS. This technique also eliminates any concerns regarding the film thickness of the dentin sealant. (J Prosthet Dent 2005;94:511-9.)

CLINICAL IMPLICATIONS

Tooth preparation for indirect bonded restorations such as composite/ceramic inlays, onlays, and veneers can generate significant dentin exposure. The results of this study indicate that freshly cut dentin surfaces may be sealed with a dentin bonding agent immediately following tooth preparation, prior to impression making. A 3-step etch-and-rinse dentin bonding agent with a filled adhesive resin is recommended for this purpose.

If a considerable area of dentin has been exposed during tooth preparation for indirect bonded restorations, it is suggested that a dentin adhesive be applied strictly according to the manufacturer's instructions. Successful dentin bonding is of particular clinical importance for inlays, onlays, veneers, and dentin-bonded porcelain crowns because the final strength of the tooth-restoration complex is highly dependent on adhesive procedures. Long-term clinical trials by Dumfahrt and Schaffer[1] and Friedman[2] showed that porcelain veneers partially bonded to dentin have an increased risk of failure. Advances in dentin bonding agent (DBA) application techniques[3-15] suggest that these failures can likely be prevented by changing the application procedure of the DBA. In fact, there are principles that should

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Immediate Dentin Sealing: A Fundamental Procedure for Indirect Bonded Restorations

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ABSTRACT

The purpose of this article is to review evidence-based principles that could help optimize dentin bonding for indirect composite and porcelain restorations. More than 30 articles were reviewed, most of them addressing the specific situation of dentin bonding for indirect restorations. It appears that the combined results of this data plus clinical experience suggest the need for a revision in the dentin bonding procedure. Immediate application and polymerization of the dentin bonding agent to the freshly cut dentin, prior to impression taking, is recommended. This new application procedure, the so-called immediate dentin sealing (IDS), appears to achieve improved bond strength, fewer gap formations, decreased bacterial leakage, and reduced dentin sensitivity. The use of filled adhesive resins (low elastic modulus liner) facilitates the clinical and technical aspects of IDS. This rational approach to adhesion also has a positive influence on tooth structure preservation, patient comfort, and long-term survival of indirect bonded restorations.

CLINICAL SIGNIFICANCE

Tooth preparation for indirect bonded restorations (eg, composite/ceramic inlays, onlays, and veneers) can generate significant dentin exposures. It is recommended to seal these freshly cut dentin surfaces with a dentin bonding agent (DBA) immediately following tooth preparation, before taking impression. A three-step total-etch DBA with a filled adhesive resin is recommended for this specific purpose. The major advantages, as well as the technical challenges of this procedure, are presented in detail.

(*J Esthet Restor Dent* 17:144–155, 2005)

DENTINOENAMEL JUNCTION AS A MODEL FOR DENTIN BONDING OPTIMIZATION

Whenever a substantial accessible area of dentin has been exposed during tooth preparation for indirect bonded restorations, local application of a dentin bonding agent (DBA) is recommended. The principles for dentin bonding are well established today based on the work of Nakabayashi and colleagues in the 1980s,[1] the principle of which is to create an interphase or interdiffusion layer, also called the hybrid layer,[2] by the interpenetration of monomers into the hard tissues. This approach was landmark because once the infiltrating resin is polymerized, it can generate a "structural" bond somewhat similar to the interphase formed at the dentinoenamel junction (DEJ).[3] Studies have shown that the DEJ can be regarded as a perfect fibril reinforced bond.[4,5] It is composed of a moderately mineralized interface between two highly mineralized tissues (enamel and dentin). Parallel-oriented coarse collagen bundles form massive consolidations that can divert and blunt enamel cracks through considerable plastic deformation. There are startling similarities between the DEJ and the current principles of

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Immediate dentin sealing supports delayed restoration placement

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Statement of problem. Immediate dentin sealing (IDS) is a new approach in indirect restorations. Dentin is sealed immediately following tooth preparation, prior to impression making. It is not known whether it is still possible to obtain an efficient bond between the resin-coated dentin and the restoration after 2 to 4 months of placement of provisional restorations.

Purpose. The purpose of this study was to determine if there were differences in microtensile bond strength to human dentin using the IDS technique when comparing 2, 7, and 12 weeks of delay until restoration placement, using 2 different dentin bonding agents (DBAs). Previously published preliminary IDS data were included for comparison.

Material and methods. Fifty freshly extracted human molars were obtained and divided into 10 groups. A 3-step etch-and-rinse DBA (Optibond FL) and a 2-step self-etching DBA (SE Bond) were used. For each DBA, the control (C) specimens were prepared using a direct immediate bonding technique and composite restoration (Z100). Preparation of the other specimens used an indirect approach without dentin prebonding (delayed dentin sealing, DDS) or with immediate dentin sealing (IDS), immediately following preparation. IDS teeth had provisional restorations (Tempfil inlay) placed for 2 weeks (IDS-2W), 7 weeks (IDS-7W), or 12 weeks (IDS-12W) before restoration placement. All teeth were prepared for a nontrimming microtensile bond strength test (MTBS) 24 hours after definitive restoration with composite overlays (Z100). Ten to 11 beams (0.9 × 0.9 × 11 mm) from each tooth were selected for testing. MTBS data obtained from the 10 experimental groups were analyzed with a 2-way analysis of variance (ANOVA, dentin bonding system, and sequence of application) with each tooth (mean MTBS from the 10-11 beams) used as a single measurement. The Tukey HSD post hoc test was used to detect pairwise differences among experimental groups (α=.05). Fractured beams were also analyzed under stereoscopic microscope (× 30) and SEM.

Results. For both adhesives, the mean microtensile bond strengths of C and all IDS groups were not significantly different and exceeded 45 MPa. DDS groups exhibited lower bond strength than all others sequences (P<.001) with SE Bond at 1.81 MPa significantly lower (P=.026) than Optibond FL at 11.58 MPa. The highest mean microtensile bond strength values were found with Optibond FL at 7 weeks (66.59 MPa) and 12 weeks (59.11 MPa). These were significantly higher than SE Bond in the same conditions with values of 51.96 MPa and 45.76 MPa (P=.001 and P=.003), respectively. Failures in DDS groups were all interfacial and purely adhesive. Both C and IDS-2W groups demonstrated interfacial failure that was typically mixed with both areas of failed adhesive resin and areas of cohesively failed dentin while IDS-7W and IDS-12W failed consistently between the existing resin coating (used during IDS) and the overlaying composite resin.

Conclusions. When preparing teeth for indirect bonded restorations, IDS with a 3-step etch-rinse or a 2-step self-etching DBA (prior to impression making) results in microtensile bond strength similar to that obtained with a freshly placed adhesive. The bond strength is not affected by up to 12 weeks of elapsed time prior to placement of the definitive restoration. (J Prosthet Dent 2007;98:166-174)

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Interactions between impression materials and immediate dentin sealing

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Statement of problem. Immediate dentin sealing is a new strategy in which a dentin bonding agent is applied to freshly cut dentin and polymerized before making an impression. Interactions are suspected between the resin coating and the impression material.

Purpose. The purpose of this study was to identify possible interactions between 2 impression materials and resin-coated tooth surfaces using 2 different dentin bonding agents.

Material and methods. Extracted molars (n=6) with flat midcoronal preparations underwent 1 of 4 procedures: control group, unsealed tooth surface/impression; IDS group, immediate dentin sealing (Optibond FL or Clearfil SE Bond)/impression; IDS/AB group, immediate dentin sealing/air blocking/impression; IDS/AB-P group, immediate dentin sealing/air blocking/pumicing/impression. All specimens underwent impressions (Impregum Soft or Extrude). Optical microscopy was used to detect unpolymerized and residual impression material on the bonded tooth surface.

Results. A substantial layer of unpolymerized resin (oxygen-inhibited layer) was found in the IDS group, which resulted in100% faulty impressions (unpolymerized impression material) for both adhesives and impression materials. Air blocking the resin coating (IDS/AB group) did not completely eliminate the oxygen-inhibited layer of Optibond FL and slightly altered the surface of SE Bond (wrinkles). Only SE Bond along with Extrude generated ideal impressions in group IDS/AB, while all other combinations of adhesive/impression material resulted in faulty impressions (unpolymerized impression material or adhesions). The IDS/AB-P group yielded ideal Extrude impressions but generated faulty Impregum impressions (adhesions) in more than 50% of the specimens.

Conclusions. Immediate dentin sealing should be followed by air blocking and pumicing to generate ideal impressions with Extrude. Impregum is not recommended in combination with immediate dentin sealing. (J Prosthet Dent 2009;102:298-305)

Clinical Implications

The results of this qualitative evaluation indicate that clinicians must be cautious when using immediate dentin sealing. The incompletely polymerized resin coating can inhibit the polymerization reaction of impression materials. Successful Extrude impressions of resin-coated surfaces can be obtained by air blocking and pumicing before making an impression. With Impregum, air blocking/pumicing results in impression defects due to adhesion and subsequent tearing of impression material.

The immediate application of a dentin bonding agent (DBA) prior to making an impression for indirect composite resin and porcelain restorations has been proposed since the early 1990s.[1-5] Immediate dentin sealing (IDS) has been significantly refined and extensively studied over the years with positive results regarding bond strength, as well marginal/internal adaptation of indirect restorations, when compared to traditional delivery techniques.[5-14] It is now an accepted approach,[15] with advantages such as immediate protection against bacterial leakage and sensitivity, patient comfort, and tissue conservation.

A problematic step in the procedure is the final impression of the resin-coated preparation surface, since

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Dental Adhesion: Mechanism, Techniques and Durability

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Contemporary dental adhesives show favorable immediate results in terms of bonding effectiveness. However, the durability of resin-dentin bonds is their major problem. It appears that simplification of adhesive techniques is rather detrimental to the long term stability of resin-tooth interface. The hydrostatic pulpal pressure, the dentinal fluid flow and the increased dentinal wetness in vital dentin can affect the intimate interaction of certain dentin adhesives with dentinal tissue. Bond degradation occurs via water sorption, hydrolysis of ester linkages of methacrylate resins, and activation of endogenous dentin matrix metalloproteinases. The three-step etch-and-rinse adhesives still remain the gold standard in terms of durability. This review discusses the fundamental process of adhesion to enamel and dentin with different adhesive techniques, factors affecting the long term bonding performance of modern adhesives and addresses the current perspectives for improving bond durability.

Keywords: *Adhesion, resin-dentin interface, hydrophilicity, durability.*
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INTRODUCTION

One of the greatest challenges in restorative dentistry is to obtain an effective seal of the tooth-restoration interface. Composite restorations rely on adhesive systems which form a micromechanical bond with the tooth structure. The original multicomponent bonding systems are gradually being replaced with simplified, consolidated adhesive systems that are more user-friendly. Despite significant improvements of adhesive systems, the bonded interface remains the weakest area of tooth-colored restorations. Although the incorporation of hydrophilic and acidic resin monomers has substantially improved the initial bonding of contemporary adhesives to intrinsically wet dental substrates, few manufacturers have recognized the potential problems associated with these increasingly hydrophilic adhesives. Most of the current dental adhesives reveal excellent immediate and short-term bonding effectiveness but the durability and stability of resin-bonded interfaces still remains questionable.[1-3] Hence, the objective of this review is to describe the fundamental process of adhesion to enamel and dentin, and to discuss the current trend of simplifying bonding in both the etch & rinse and self-etch adhesives along with the potential *in vivo* degradation processes involved and various strategies to optimize bonding effectiveness.

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Dentin as a Bonding Substrate

Unlike enamel bonding which is obtained with relative ease, bonding to dentin has continued to be a challenge. This is partly due to the biological characteristics of dentin, namely, its high organic content, its tubular structure with presence of odontoblastic processes, the continuous moist condition due to presence of dentinal fluid, intratubular pressure and permeability of the dentin.[4] Although enamel is a highly mineralized tissue composed of more than 90% (by vol) hydroxyapatite, dentin contains substantial proportion of water and organic material, primarily type 1 collagen.[5] Dentin is an intrinsically hydrated tissue, penetrated by a maze of 1 to 2.5μm diameter fluid-filled dentinal tubules and the intertubular dentin contains collagen fibrils with the characteristic collagen banding. There is continuous transudation of dentinal fluid due to intrapulpal pressure in vital dentin that has a magnitude of 25 to 30 mm Hg or 34 to 40 cm of water.[6,7] The number of tubules decreases from about 45000/mm^2 close to the pulp to about 20000/mm^2 near the DEJ.[8] The average tubule diameter ranges from 0.63 μm at the periphery to 2.37 μm near the pulp.[9] The tubules occupy an area of only 1% of total surface near the DEJ, whereas they occupy 22% of the surface close to the pulp.[10] That also means that the water content of superficial dentin is only 1% whereas it is 22% near the pulp.

Dentin permeability is an important factor affecting

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Adhesive systems: important aspects related to their composition and clinical use

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ABSTRACT

This literature review article addresses the types and the main components of different etch-and-rinse and self-etch adhesive systems available in the market, and relates them to their function, possible chemical interactions and influence of handling characteristics. Scanning electron microscopy (SEM) images are presented to characterize the interface between adhesives and dentin. Adhesive systems have been recently classified according to their adhesion approaches in etch-and-rinse, self-etch and glass ionomer. The etch-and-rinse systems require a specific acid-etch procedure and may be performed in two or three steps. Self-etch systems employ acidic monomers that demineralize and impregnate dental substrates almost at the same time. These systems are separated in one or two steps. Some advantages and deficiencies were noted for etch-and-rinse and self-etch approaches, mainly for the simplified ones due to some chemical associations and interactions. The SEM micrographs illustrate different relationships between adhesive systems and dental structures, particularly dentin. The knowledge of composition, characteristics and mechanisms of adhesion of each adhesive system is of fundamental importance to permit the adoption of ideal bonding strategies under clinical conditions.

Key words: Dentin-bonding agents. Dentin. Dental adhesives. Chemical composition.

INTRODUCTION

Throughout the last decades adhesive systems have received different classifications, generally based on modifications in their compositions. These practices led to several complex and confusing classifications that have brought some difficulties to clinicians for selection and use of dental adhesives. Van Meerbeek, et al.[39] (2003) proposed a simple classification based on the interaction of adhesives with dental substrates and number of steps: etch-and-rinse (two- and three-step adhesives), self-etch (one- and two-step adhesives) and glass ionomer. All of them have received important modifications in the last years. These modifications were made based on the increasing of knowledge of their compositions and adhesion mechanisms. Indeed, the best understanding of the role of dental substrates in the adhesion process has helped researchers and manufacturers developing and improving dental adhesion.

This literature review article addresses the types and the main components of different etch-and-rinse and self-etch adhesive systems available in the market, and relates them to their function, possible chemical interactions and influence of handling characteristics.

Etch-and-rinse ADHESIVE systems

Etch-and-rinse adhesive systems can be either three- or two-step materials depending on whether primer and bonding are separated or combined in a single bottle. The adhesion strategy involves at least two steps and, in its most conventional form, three steps with successive application of the conditioner

Critical Review
Dental Materials/Dentistry

Bonding efficiency and durability: current possibilities

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Abstract: Bonding plays a major role in dentistry nowadays. Dental adhesives are used in association with composites to solve many restorative issues. However, the wide variety of bonding agents currently available makes it difficult for clinicians to choose the best alternative in terms of material and technique, especially when different clinical situations are considered. Moreover, although bonding agents allow for a more conservative restorative approach, achieving a durable adhesive interface remains a matter of concern, and this mainly due to degradation of the bonding complex in the challenging oral environment. This review aims to present strategies that are being used or those still in development which may help to prevent degradation. It is fundamental that professionals are aware of these strategies to counteract degradation as much as possible. None of them are efficient to completely solve this problem, but they certainly represent reasonable alternatives to increase the lifetime of adhesive restorations.

Keywords: Dentin-Bonding Agents; Dental Cements; Adhesives; Dental Enamel.

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Introduction

The advent of adhesives and the understanding of their interaction mainly with dentin have recognizably become landmarks for the practice of operative and conservative dentistry. In addition to direct resin restorations of teeth compromised by fractures, carious or non-carious lesions, adhesives enable several other procedures, such as bonding of indirect restorations, intra radicular posts and orthodontic brackets, repair of failed restorations, control of dentin hypersensitivity and correction of aesthetic impairments.

For a long time, amalgam was the material of choice for directly restoring posterior damaged teeth, leading to the preparation of large and geometric macro-retentive cavities. However, as recently presented by Alexander et al.,[1] the United Nations Environment Programme (UNEP), supported by the World Health Organization (WHO), has urged for policies that could play down the use of mercury, and consequently of dental amalgam. This trend was also corroborated by the Minamata Convention, which strengthened the so-called phase-down of amalgam.[2] Despite many controversies about its suitability as a real alternative to amalgam, resin composites gradually turned out to be the most indicated restorative material, also for posterior

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Invited Overview Article

Dentin Permeability: The Basis for Understanding Pulp Reactions and Adhesive Technology

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Permeability involves the passage of fluids, ions, molecules, particulate matter and bacteria into and through a substance or tissue under different and varying conditions. The permeability of the dentin is essential to support the physiology and reaction patterns of the pulp-dentin organ. Nutrients and impulses are transported from the pulp via the odontoblast process and the contents of its tubules maintain the dentin as a vital tissue. However, the main interest of this paper focuses on penetration from the outside towards the pulp rather than from the pulp towards the outside. The present overview centers on the dentinal tubules; how they are formed and how they change as a result of normal and abnormal function, age, and pathological processes and the effect of these processes on the permeability of dentin. Particular attention is focused on the patency of the dentinal tubules.This overview is largely based on the author's own research, clinical insights and active participation in continuing dental education over the last 50 years. It is not a review of the literature related to the permeability of dentin. Rather it presents interpretation of results related to the permeability of dentin based on experience and opinions acquired over a lifetime in dental research.

Key Words: dentinal tubules, age changes, caries, smear plugs, adhesive dentistry.

INTRODUCTION

This review will deal with variations in the structure of the dentin and its effect on the permeability of the dentin. Dentin may have open tubules as in newly erupted teeth and in other situations and in specific locations, it may have tubules that are partly or completely obturated or occluded by mineralized deposits. Some parts of root dentin have relatively few tubules. These differences will affect the permeability of the tissue, including the transfer of noxious agents, and consequently variation in dentin permeability will have an effect on pulp reactions. Furthermore, occluded tubules cannot be penetrated by restorative materials. Thus, the permeability of dentin becomes an integral part of modern restorative dentistry where adhesive technology plays a central role. The patency of dentinal tubules will therefore be a focal theme in this review.

Pulp-Dentin Complex

The outer periphery of the dentin is greater at the periphery than at the pulp-dentin border, especially in the crown part of the tooth. Since the dentinal tubules are cylindrical in shape and extend through the entire width of the dentin, the density of tubules is greater near the pulp than peripherally. In addition the branching of the tubules varies in different parts of teeth resulting in distinct differences in the structure of dentin (1). These differences are likely to affect the permeability of the tissue. In addition, post eruptive changes take place in dentin as a result of age and functional stimuli as well as by pathological processes like caries throughout the life of the tooth. In this review emphasis will be placed on the structural changes that affect the permeability of the tissue.

The dental pulp is one of a few tissues in the body that exhibit a normal relatively high interstitial tissue fluid pressure. This means that a pressure gradient exists in dentinal tubules under normal conditions. Anything trying to penetrate through the dentin towards the pulp must do so against a pressure gradient while anything penetrating from the pulp will be facilitated by the same pressure gradient provided the pulp is vital. This pressure gradient can be imitated *in vitro* by using an experimental design to compensate for the pressure

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Hybrid Layer as a Dentin-Bonding Mechanism

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A number of mechanisms (both mechanical and chemical) have been proposed as the cause of dentin adhesion. Extensive research in Japan during the past 10 years has shown that strong, long-lived bonds between resin and living dentin will form when a monomer such as 4-META, which contains both hydrophilic and hydrophobic chemical groups, penetrates the tissue and polymerizes in situ. This resin-impregnation creates a transitional "hybrid" layer, that is neither resin nor tooth, but a hybrid of the two. The thin layer of resin-reinforced dentin locks the two dissimilar substances together on a molecular level, sealing the surface against leakage and imparting a high degree of acid resistance.

Once Dr. Buonocore pointed the way, it became apparent that strong, durable bonds to etched enamel were relatively easy to create.[1] However, similar success bonding to dentin has remained elusive. The problem, of course, is the fundamental difference in the nature of the two tissues.

Enamel is largely inert, composed primarily of hydroxyapatite with very low water content.

Dentin, on the other hand, is living tissue. Its chemical structure involves both inorganic and organic materials, and it features a highly complex physical structure that varies with the depth of the tissue. Depending on the particular tooth, the age of the patient, and the depth of the preparation, the substrate surface can consist of widely varying proportions of intertubular dentin, peritubular dentin, and sclerotic dentin. The dentin may be very dense...or highly porous. Near the dentin-enamel junction (DEJ) only 1 percent of the surface area consists of tubules. Near the pulp, tubules can comprise as much as 22 percent of the surface area.[2] Furthermore, those tubules communicate with a very vulnerable pulp that reacts adversely to mechanical, thermal, biological, or chemical insult. And to make matters worse, the dentin is saturated with oxygen and water. Though water content varies according to the type and depth of dentin, approximately 13 percent of overall dentinal volume is fluid.[3]

Is it possible to chemically bond to dentin? Twenty years ago the research community believed it was, and the first two generations of dentin "adhesives" claimed to create chemical bonds to the dentin. Unfortunately, these agents performed much better in the laboratory than in the mouth. With the exception of covalent bonds, chemical bonds are vulnerable to degradation in the oral environment, which results in leakage, discoloration, and secondary caries.

Based on research conducted over the past decade at the Institute of Medical and Dental Engineering, the authors have seen little to indicate that durable graft polymerization (i.e., chemical adhesion) to ground dentin can be achieved. First of all, it is extremely difficult to achieve effective chemical reaction when one of the materials is a solid, because the frequency of molecular collisions is very low. (Most chemical reactions are designed to take place in solution.) Furthermore, there are a number of limiting criteria that any chemical reaction involving dentin would have to meet:

1. It would have to occur at body temperature.
2. It must not involve monomers or catalysts that might injure the pulp.
3. The reaction must be completed within 10 minutes.

HYBRID

In 1963 Masuhara et al reported that when tri-n-butyl borane (TBB) was used as an initiator, methyl methacrylate (MMA) chemically grafted to the collagen in wet ivory and produced an excellent bond.[4] The

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Adhesive sealing of dentin surfaces in vitro: A review

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ABSTRACT: Purpose: This review describes the evolution of the use of dental adhesives to form a tight seal of freshly prepared dentin to protect the pulp from bacterial products, during the time between crown preparation and final cementation of full crowns. The evolution of these "immediate dentin sealants" follows the evolution of dental adhesives, in general. That is, they began with multiple-step, etch-and-rinse adhesives, and then switched to the use of simplified adhesives. **Methods:** Literature was reviewed for evidence that bacteria or bacterial products diffusing across dentin can irritate pulpal tissues before and after smear layer removal. Smear layers can be solubilized by plaque organisms within 7-10 days if they are directly exposed to oral fluids. It is likely that smear layers covered by temporary restorations may last more than 1 month. As long as smear layers remain in place, they can partially seal dentin. Thus, many in vitro studies evaluating the sealing ability of adhesive resins use smear layer-covered dentin as a reference condition. Surprisingly, many adhesives do not seal dentin as well as do smear layers. **Results:** Both in vitro and in vivo studies show that resin-covered dentin allows dentin fluid to cross polymerized resins. The use of simplified single bottle adhesives to seal dentin was a step backwards. Currently, most authorities use either 3-step adhesives such as Scotchbond Multi-Purpose or OptiBond FL or two-step self-etching primer adhesives, such as Clearfil SE, Unifil Bond or AdheSE. (*Am J Dent* 2015;28:321-332).

CLINICAL SIGNIFICANCE: Although newly developed adhesive resins have attempted to improve dentin sealing, many such attempts failed. The use of two-step self-etching primer adhesives that combine the use of an acidic primer with a solvent-free adhesive layer provide excellent sealing in vitro. The use of three-step, etch-and-rinse adhesive systems like Scotchbond Multi-Purpose or OptiBond FL, that also use solvent-free adhesives, seal dentin very well, in vitro.

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Introduction

When indirect restorations are used to restore function, dentists must seal the exposed dentin with temporary materials during the interval required to fabricate and cement the final restoration. Full crown preparations expose up to 1 cm^2 of dentin that contains more than 3 million tubules/cm^2.[1] Such tubules represent millions of microscopic "pathways to the pulp" because they all terminate in the tooth pulp. Both enamel and cementum are impermeable and nerve-free. These peripheral seals have very low permeabilities. However, once these surface sealing hard tissues are removed from dentin surfaces, the exposed dentin becomes highly permeable and very sensitive to hydrodynamic stimuli.[2] Because dentin tubules contain collagen fibrils/fibers, constrictions, etc., their functional diameter (0.1 µm) is far smaller than their 1.0 µm anatomical diameter.[3] This allows dentin to function like a 0.1 µm Millipore filter to prevent bacteria from invading the pulp via dentin tubules. However, soluble bacterial products can permeate through dentin to the pulp where they provoke immunological reactions and pulpal inflammation that threaten pulpal health.[4-6]

Prevention of pulpal inflammation

Current prosthodontists recommend conservative tooth preparations using copious air-water spray and intermittent cutting. This is followed by temporizing the preparations using a variety of temporary filling materials and crown formers as long as there are no pre-existing signs of pulp pathology. The rationale is that a healthy pulpo-dentin complex reacts to tooth preparation by the deposition of tertiary dentin under those tubules that were cut during cavity preparation which should wall off the prepared dentin and prevent bacterial invasion.[7]

On the other hand, old teeth have smaller pulps with fewer mesenchymal cells, and a poorer blood supply.[8] Tertiary dentin requires more than 30 days to begin to form and that dentin will not form if the pulp under the cut tubules produces an inflammatory response.[7] Old pulps contain pulp stones that interfere with endodontic treatment. If, during temporization, the temporary is lost and the cut dentin is exposed, bacterial products will begin to diffuse down the tubules toward the pulp. Pulpal cells react to these bacterial antigens as if actual bacteria were invading the pulp. This will trigger neurogenic inflammation in the pulp leading to pulpal symptoms.[9,10]

Those that advocate immediate dentin sealing (IDS) of freshly prepared dentin seek to protect the pulp from bacteria and bacterial products, using adhesive resins.[11-24] These resins should prevent dentin fluid from permeating from inside dentin, through polymerized resin to the surface. The resins should also prevent the inward diffusion of bacterial products through the polymerized resin. This involves acid-etching dentin with 37% phosphoric acid for 15 seconds when using etch-and-rinse adhesives. When using self-etching adhesives, the two-bottle primer adhesives are preferred over single-bottle systems because the acidic primer is covered with a solvent-free adhesive, rich in dimethacrylates that create stronger resin films than monomethacrylates. Thicker resin seals are better than thinner coatings, because they are less likely to be lacerated by try-ins, etc.

Combinations of resin adhesives covered by flowable composites provide tougher IDS than resin films alone. Optibond FL[a] is an example of a 3-step, etch-and-rinse adhe-

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Review

Concept and clinical application of the resin-coating technique for indirect restorations

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The resin-coating technique is one of the successful bonding techniques used for the indirect restorations. The dentin surfaces exposed after cavity preparation are coated with a thin film of a coating material or a dentin bonding system combined with a flowable composite resin. Resin coating can minimize pulp irritation and improve the bond strength between a resin cement and tooth structures. The technique can also be applied to endodontically treated teeth, resulting in prevention of coronal leakage of the restorations. Application of a resin coating to root surface provides the additional benefit of preventing root caries in elderly patients. Therefore, the coating materials have the potential to reinforce sound tooth ("Super Tooth" formation), leading to preservation of maximum tooth structures.

Keywords: Resin-coating technique, Resin cement, Bonding to dentin, Indirect restoration, Acid-base resistant zone

INTRODUCTION

With the improvement of adhesive materials and their greater reliability, adhesive materials and technology have been accepted in the clinic and have revolutionized clinical procedures in dentistry, especially in operative dentistry, prosthodontics, and orthodontics. The resin-coating technique is a successful bonding technique used for indirect restorations. The clinical application of the resin-coating technique was proposed in the early 1990s by Japanese clinicians who were experts in adhesive dentistry. The dentin and enamel surfaces exposed after cavity preparation are coated with a thin film of a coating material or a dentin bonding system combined with a flowable composite resin. Magne *et al.*[1,2] reported a similar idea, immediate dentin sealing (IDS), to seal the exposed dentin using a coating material. However, IDS focuses only on the dentin surface but not on the enamel surface. In the resin-coating technique, the exposed enamel and dentin surfaces after preparation should be totally covered by the coating layer. The technique can be applied not only to vital teeth but also to non-vital teeth after endodontic treatment.

The adhesive resin coating applied to dentin surfaces provides protection for dentin and pulp[3-5] through the formation of a hybrid layer[6] because of the superior acid resistance of resin as compared to tooth substances. Previous studies have demonstrated that the resin-coating technique improves resin cement-dentin bonding when restorative materials are subsequently placed on tooth crowns in an indirect restoration procedure[7-10]. A resin coating applied to the exposed dentin surfaces has an additional advantage of significantly reducing pain caused by external physical stimuli because it seals dentinal tubules and, thus, remarkably decreases dentinal permeability[11-13].

The concept and clinical applications of the resin-coating technique are reviewed in this paper using the previous literature.

PROTECTING AND FORTIFYING TOOTH SUBSTANCES

Leaving undercuts in the cavity after the removal of carious lesions is unacceptable with conventional indirect restorations, including inlays and onlays. Therefore, the undercuts are commonly eliminated by removing sound tooth structure. In contrast, the undercuts are filled with a flowable composite resin as a blockout procedure in the resin-coating technique, thereby avoiding excessive removal of tooth substances[14]. Sound dentin exposed in the interior of a cavity needs to be blocked against external stimuli. It has been reported that adhesion between a self-adhesive resin cement and tooth substance is generally lower than the adhesion achieved by direct resin composite

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Microtensile Bond Strengths to Cavity Floor Dentin in Indirect Composite Restorations using Resin Coating

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ABSTRACT

Purpose: The aims of this study were (1) to evaluate the effect of a resin coating on the microtensile bond strengths (μ-TBSs) of indirect composite restorations bonded to dentin with resin cement and (2) to compare the μ-TBSs with that of a directly placed composite.

Materials and Methods: Class I cavities were prepared in extracted human molars. The specimens were divided into five groups: For the indirect restorations, the cavity surfaces of the control group were left uncoated (group 1), while the surfaces of the experimental groups were resin coated with a dentin bonding system, Clearfil Protect Bond (PB; groups 2 and 3), or with a combination of PB and a flowable resin composite, Protect Liner F (PLF; group 4). The cavities were temporized for 1 day. Indirect composite restorations (Estenia) were cemented with a resin cement (Panavia F). Pretreatment with ED Primer II was performed in the groups 1, 3, and 4. For the direct restorations, the cavities were restored with PB and a direct composite (Clearfil AP-X; group 5). After 24 hours of water storage, μ-TBSs were measured at a crosshead speed of 1 mm/min. The data were analyzed with one-way analysis of variance and Sheffe's test ($p < 0.05$). In addition, fracture modes were determined visually and by scanning electron microscopy.

Results: A combination of PB and PLF showed significantly higher bond strengths compared with the original bond strength of Panavia F and the single use of PB ($p < 0.05$). However, the highest bond strengths were obtained when PB was used for direct composite restorations ($p < 0.05$).

Conclusion: The application of a resin coating consisting of a self-etching primer dentin bonding system and a flowable resin composite significantly improved the μ-TBS of indirect restorations bonded to dentin using resin cement.

CLINICAL SIGNIFICANCE

A resin coating should be required to improve dentin bonding performance of Panavia F in indirect restorations. However, direct composite restorations still provide higher bond strength compared to indirect restorations.

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Dentin bond strengths of two ceramic inlay systems after cementation with three different techniques and one bonding system

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Statement of problem. Cementation of inlay restoration is critical. Because of its high organic content, dentin is a less favorable substrate for bonding than enamel. Therefore it is important to improve dentin adhesion when placing ceramic inlay restorations.

Purpose. The purpose of this study was to compare the dentin bond strengths of 2 different ceramic inlay systems after cementation with 3 different techniques and 1 bonding system.

Material and methods. One hundred twenty freshly extracted caries- and restoration-free molar teeth used in this study were stored in saline solution at room temperature. Standardized Class I preparations were made in all teeth. Each preparation had a length of 6 mm, a width of 3 mm, a depth of 2 mm, and 6-degree convergence of the walls. Teeth were randomly assigned to 2 groups of 60 each to evaluate the bonding of 2 ceramic systems, Ceramco II (Group I) and IPS Empress 2 (Group II), to dentin. Each of the 2 groups were further divided into 3 cementation technique groups of 20 each (Group I A, B, and C and Group II A, B, and C). Groups I A and B and Groups II A and B used dentin bonding agent (DBA) Clearfil Liner Bond 2V, and resin cement (Panavia F). Groups I C and II C served as control groups and used Panavia F without the dentin-bonding agent. In Groups I A and II A, the DBA was applied immediately after the completion of the preparations (D-DBA). Impressions were then made, and the ceramic inlays were fabricated according to the manufacturers' guidelines. In Groups I B and II B the DBA was applied just before luting the inlay restorations (I-DBA). In Groups I C and II C, no bonding agent was used before the cementation of the inlay restorations (No DBA). Cementation procedures followed a standard protocol. After cementation, specimens were stored in distilled water at 37° C for 24 hours. The teeth were sectioned both mesial-distally and buccal-lingually along their long axis into three 1.2 × 1.2 mm wide l-shaped sections. The specimens were then subjected to microtensile testing at a crosshead speed of 1 mm/min, and the maximum load at fracture (in kilograms) was recorded. Two-way analysis of variance and Tukey honestly significant difference tests were used to evaluate the results ($P<.05$). Scanning electron microscopy analysis was used to examine the details of the bonding interface. The fractured surfaces were observed with a stereomicroscope at original magnification ×22 to identify the mode of fracture.

Results. Although no significant difference was found among the 2 ceramic systems with regard to dentin bond strengths ($P>.05$), the difference between the cementation techniques was found to be significant ($P<.001$). Comparison among techniques showed that the dentin bond strength in the D-DBA technique had a significantly higher mean (40.27 ± 8.55 Kg) than the I-DBA (30.20 ± 6.78 Kg) and No DBA techniques (32.43 ± 8.58 Kg). As a result of scanning electron microscopy analysis, a distinct and thicker hybrid zone with more, and longer resin tags were found in specimens treated with the D-DBA technique than with the other 2 techniques. Most failures (353 of 360) were adhesive in nature at the bonding resin/dentin interface. Only 7 specimens showed cohesive failure within the bonding resin.

Conclusion. Within the limitations of this in vitro study, the cementation of the ceramic inlays tested with the D-DBA technique used resulted in higher bond strengths to dentin. (J Prosthet Dent 2003;89:275-81.)

CLINICAL IMPLICATIONS

In this in vitro study, the dentin bonding agent tested, when placed immediately after the completion of preparation, resulted in better bond strengths to dentin with the cement tested.

Patients' esthetic expectations have increased for the posterior, as well as anterior, region.[1] Although amalgam restorations have improved physical and chemical properties, they provide questionable esthetic results.[2,3] With the developments in adhesive dentistry, composite restorations have become popular. Composite restorations exhibit problems such as color stability, wear resistance, polymerization contraction, and microleakage. Ceramic inlays combining esthetics with wear resistance have been developed for restoration of posterior teeth.[2,4,5-8] Clinical success with ceramic inlays/onlays has been assisted by the ability to develop a reliable bond of composite to dental tissues.[9,10]

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IDS: Immediate Dentin Sealing (IDS) for Tooth Preparations

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Do	Why
Freshly cut exposed dentin with a diamond bur (if etch-and-rinse approach) or carbide tungsten bur (if self-etching approach).	To remove all contaminants from the dentin surface
Apply dentin bonding agent according to manufacturer's instruction (3-step etch-and-rinse or 2-step self-etching recommended). Apply thick layer of adhesive resin (filled adhesive resin recommended) and light polymerize. If using unfilled adhesive, protect with layer of flowable resin and light polymerize.	To seal exposed dentin with a consistent resin coating layer
Optional: use regular restorative composite resin to correct geometry, elevate preparation, or fill in undercuts.	To reinforce remaining cusps and improve preparation design
Cover tooth preparation with glycerin gel and light polymerize for 10 s (air blocking), rinse away with air/water spray.	To reduce the thickness of the oxygen-inhibited layer
Re-finish enamel margins with a diamond bur.	To eliminate excesses of adhesive resin
Before elastomeric impression, gently pumice tooth preparation with soft rubber cup.	To eliminate debris and residues of the oxygen inhibited layer
Proceed with impression (optical CAD/CAM or elastomeric)	To fabricate inlay, onlay veneer, or crown
Cover preparation with isolating medium (petroleum jelly) before applying provisional resin.	To avoid locking of provisional restoration
At restoration delivery: 1) gently air abrade preparation and etch enamel with H3PO4 and 2) use resin-based luting agent (and adhesive resin if necessary to wet preparation).	To 1) remove/clean debris for bonding and 2) bond restoration

IAAD WORKING INSTRUCTIONS

There is a strong body of evidence to support applying an adhesive resin coating to the freshly cut dentin according to the manufacturer's instructions[1-9] when a significant area of dentin has been exposed during tooth preparation for indirect restorations, such as inlays, onlays, veneers, and even crowns. Freshly cut and clean dentin is ideal for dentin bonding.[11] IDS enables the pre-polymerization of the dentin bonding agent, resulting in improved bond strength.[5,6,8,9,12] Delaying restoration placement allows the dentin bond to develop without stress during the provisional restoration stage.[13] When used for traditional crown preparations, IDS can result in significantly increased retention, reduced marginal leakage, improved bond strengths, and decreased postoperative sensitivity.[14-16,18] Practical reasons to justify IDS[1,10,17] include the fact that the clinician can focus on the "wet bonding" to dentin, while dry enamel bonding can be performed at the stage of restoration luting; the sealed dentin is protected from bacterial leakage/infiltration during the provisional restoration, thus enhancing patient comfort. The potential risk of postcementation sensitivity is also reduced, and the cementation of the definitive restoration requires only limited or no anesthesia, ultimately facilitating occlusal adjustment.

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Un protocolo audaz (y sin embargo ortodoxo) para el sellado inmediato de la dentina vital tallada para prótesis

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An audacious protocol (and nevertheless, an orthodox one) for the immediate sealing of the vital dentin once it has been prepared for prosthodontics

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Doctor en Medicina y Cirugía. Estomatólgo

Resumen: Se detalla, paso a paso, una técnica para obtener un sellado fiable de los túbulos dentinarios de los muñones recién tallados para prótesis. La técnica está basada en una combinación de los métodos adhesivos utilizados en la actualidad.

Palabras clave: Sellado dentinario, Adhesión, Adhesivos autopolimerizables, Prótesis, Sensibilidades postoperatorias, Primer, Bondin, Túbulos dentinarios.

Abstract: A technique to obtain a confident sealing of the dentinal tubules of the teeth just prepared for prosthodontic restorations is explained. The technique is based on a combination of the adhesive methods used today.

Key words: Dentinal sealing, Adhesion, Self-curing adhesives, Prosthodontics, Postoperative sensitivity, Primer, Bonding, Dentinal tubules.

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Porcelain Veneers: Dentin Bonding Optimization and Biomimetic Recovery of the Crown

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Purpose: The purpose of this study was to investigate the biomimetic principle in porcelain veneer reconstruction, or in other words, to assess the extent to which the restoration can mimic the biomechanics and structural integrity of the original tooth. Using an optimized luting procedure, porcelain veneers are expected to present such features even when bonded to an extensive dentin surface. **Methods and Materials:** Dentin-bonded porcelain veneers were assessed using functional and cyclic thermal loads with respect to two parameters: coronal stiffness (investigated using experimental strain gauges and finite element analysis) and morphology of the tooth-restoration interface (scanning electron microscope evaluation). Two different application modes of the same dentin-bonding agent, Optibond FL, were evaluated: a traditional method (dentin adhesive applied when proceeding to luting the veneer) and an alternative method (dentin adhesive applied to dentin and cured before taking the impression for the veneer). **Results:** In the finite element model, the crown compliance increased by a factor of 2.16 after facial enamel removal and returned to 96% of its original value after the placement of the veneer. The finite element values showed a good correlation with strain gauge experimental results (one-sample *t* test, $P > 0.35$ after facial enamel removal and $P > 0.19$ after veneer placement). The dentin adhesive application mode was not critical to the recovery of tooth stiffness (analysis of variance, $P = 0.10$). However, qualitative scanning electron microscope observations demonstrated that the traditional dentin adhesive application was associated with bonding failures between the hybrid layer and the overlying resin, whereas unbroken and continuous interfaces were obtained with the new method using the same dentin adhesive. **Conclusion:** The results of this study definitely favor the biomimetic behavior of porcelain veneers bonded to teeth using an optimized application mode of dentin adhesives, because this treatment modality proved to restore both the mechanical behavior and microstructure of the intact tooth. *Int J Prosthodont 1999;12:111–121.*

Modern concepts in medical research involve the investigation of both structures and physical functions of biologic "composites" and the designing of new and improved substitutes.[1] This newly emerging interdisciplinary material science is called "biomimetics." The primary meaning refers to material processing in a manner similar to the oral cavity, such as the calcification of a soft tissue precursor. The secondary meaning of biomimetics refers to the mimicking or recovery of the biomechanics of the original tooth by the restorative material. This of course is the goal of restorative dentistry.

It is assumed that the hardness of enamel protects the soft underlying dentin. On the other hand, the crack-arresting effect of dentin and of the thick collagen fibers at the dentinoenamel junction[2] compensate for the inherently brittle nature of enamel. This structural and physical interrelationship

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DENTINE PERMEABILITY AND ITS ROLE IN THE PATHOBIOLOGY OF DENTINE SENSITIVITY

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Summary—The classical hydrodynamic theory implicated fluid movement as a transducing mechanism in the production of dental sensitivity. This theory assumes that sensitive dentine must be permeable. Various measurements of dentine permeability are discussed, including: (1) factors that influence diffusive permeation across dentine; (2) factors that influence convective fluid movement across dentine; (3) osmotic activities of solutions; (4) comparison of evaporative and convective fluid movement; (5) the interaction between outward convective fluid flux on the inward diffusive flux of molecules; and (6) the importance of pulpal blood flow in the clearance of noxious substances from dentine and pulp, a balance concept. The variables involved in achieving good penetration of desensitizing agents in the presence of outward movement of dentinal fluid are also discussed, along with the presentation of a new hypothesis which emphasizes the importance of dentine as a dynamic physiological barrier that works in harmony with neurovascular elements in the pulp in an attempt to maintain the health of the pulp–dentine complex.

Key words: permeability, hydrodynamic theory, dentinal fluid, pulpal blood flow.

INTRODUCTION

The hydrodynamic theory of dentine sensitivity is based upon the premise that sensitive dentine is permeable. It also assumes that pulpal nerves are functioning properly. Increases in dentine sensitivity might be due to increases in the rate of fluid flow across dentine or an increase in nerve excitability or both. As the mechanism responsible for coupling painful stimuli with activation of pulpal nerves involves fluid movement across dentine (Brännström, 1966), we focused on developing methods for measuring the hydraulic conductance of dentine. The hydraulic conductance (*Lp*) of a tissue expresses the ease with which fluid can move across a unit surface area under a unit pressure per unit of time (Pashley, 1990). Methods have been developed to measure the hydraulic conductance of dentine both *in vitro* and *in vivo* (Pashley, 1990; Vongsavan and Matthews, 1992a).

The hydraulic conductance of dentine is determined by a number of variables, which include the pressure moving fluid across the dentine, the length of the dentinal tubules, the viscosity of the fluid and the radius of the tubule (Pashley, 1990). The most important variable is the radius of the dentinal tubules raised to the fourth power. Small changes in the functional radius of tubules can have a very large effect on fluid flow because of the large exponent. Individuals may have smear layers on exposed root dentine that reduce the radius of their tubules, that slowly dissolve over time or that dissolve rapidly when they eat or drink citrus products; this would certainly increase dentine sensitivity (Hirvonen, Närhi and Hakumäki, 1984). As pulpal pressure is greater than atmospheric pressure (Heyeraas and Kvinnsland, 1992; Vongsavan and Matthews, 1992a; Ciucchi *et al.*, 1993), dentinal fluid is always seeping across exposed, permeable dentine, albeit at a rate too slow to activate pulpal mechanoreceptors. Anything that increases this pressure gradient may increase the outward movement of fluid enough to cause pain. Hypertonic substances ranging from foods to dentifrices can sufficiently accelerate the outward fluid movement to cause pain. Changes in the viscosity of dentinal fluid can also modify the rate of fluid flow across dentine. Dentifrices contain detergents such as sodium dodecyl sulphate. These agents could theoretically increase the fluid flow rate across dentine, even if all other variables were held constant. We have observed this reaction *in vitro* in experiments evaluating the efficacy of dentifrices at reducing the hydraulic conductance of dentine. If one does not carefully rinse all residual traces of dentifrice and sodium dodecyl sulphate from dentine, one can measure an apparent increase in dentine permeability following treatment with dentifrices, which disappears as the sodium dodecyl sulphate is slowly rinsed from the dentine surface (D. H. Pashley, unpublished). Decreases in the length of dentinal tubules also increase dentine sensitivity. This occurs slowly over time when people brush incorrectly and too aggressively, causing abrasion of the root surface. The dentine is also immediately made thinner by dental restorative procedures.

The measurement of hydraulic conductance is the easiest and most convenient measure of dentine permeability. Changes in the hydraulic conductance

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Microtensile bond strengths of one- and two-step self-etch adhesives to bur-cut enamel and dentin

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Abstract

Purpose: To evaluate the bonding effectiveness of one- and two-step self-etch adhesives in comparison with a total-etch approach.

Methods: From 55 non-carious human third molars, mid-coronal dentin and enamel bur-cut surfaces were prepared. The bonding surfaces were treated strictly following the manufacturers' instructions with three one-step self-etch (all-in-one) adhesives, AQ bond, Reactmer and Xeno CF Bond; two two-step self-etch adhesives, experimental ABF and Clearfil SE Bond, one two-step total-etch adhesive, Prime & Bond NT, and one three-step total-etch adhesive, OptiBond FL. Composite built-ups were made using Z100. After storage overnight in 37 degrees C water, the bonded specimens were sectioned into rectangular slabs of approximately 2x2 mm width and 9 mm length. They were then trimmed into a round cross-sectional shape resulting in an interface area of approximately 1 mm2, and subsequently subjected to microtensile bond strength (microTBS) testing with a cross-head speed of 1 mm/minute. Differences in microTBS were determined for enamel and dentin using the Kruskal-Wallis test at $P < 0.05$.

Results: The microTBS to enamel varied from 10.3 MPa for the one-step self-etch adhesive AQ bond to 49.5 MPa for the total-etch adhesive Prime & Bond NT. The microTBS to dentin varied from 15.5 MPa for the one-step self-etch adhesive Reactmer to 59.6 for the three-step total-etch adhesive OptiBond FL. The microTBS of the total-etch adhesives to enamel was significantly higher than that of the one-step self-etch adhesives. Comparing the dentin microTBS, only OptiBond FL performed significantly better than the one-step self-etch adhesives. Specimen failure during preparation occurred with each one-step adhesive, but more frequently when bonding to enamel than to dentin. Most one-step self-etch adhesives failed predominantly adhesively between the tooth substrate and the bonding layer in contrast to the two- and three-step adhesives that revealed generally more mixed adhesive-cohesive failures.

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Dentine bonding--the effect of pre-curing the bonding resin

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Abstract

The 24-hour shear bond strength of two dentine bonding agents was determined under two conditions. In the first, the adhesive bonding resin was cured prior to placing and curing the composite. In the second, the adhesive resin and composite were cured together. Significantly greater bond strength values were obtained for both materials using the first conditions. These differences in bonding characteristics are likely to be significant from a clinical viewpoint as well as from a statistical viewpoint. It is concluded that there is a need to establish the adhesive-dentine bond before applying and curing the composite.

Dynamics of the Pulpo-Dentin Complex

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ABSTRACT: Dentin has a relatively high water content due to its tubular structure. Once dentin is exposed, this intratubular water is free to move in response to thermal, osmotic, evaporative, or tactile stimuli. Fluid shifts across dentin are thought to cause sufficient shear forces on odontoblasts, nerve endings, nearby fibroblasts, and blood vessels to cause significant mechanical irritation, disruption, or damage, depending on the magnitude of the fluid shift. Even in the absence of fluid shifts, the water-filled tubules provide diffusion channels for noxious (i.e., bacterial products) substances which diffuse inward toward the pulp, where they can activate the immune system, provide chemotactic stimuli, cytokine production, and produce pain and pulpal inflammation. Viewed from this perspective, dentin is a poor barrier to external irritants.

However, pulpal tissues react to these challenges by increasing the activity of nerves, blood vessels, the immune system, and interstitial fluid turnover, to make the exposed dentin less permeable either physiologically, via increased outward fluid flow, or microscopically, by lining tubules with proteins, mineral deposits, or tertiary dentin, thereby enhancing the barrier properties of dentin, and providing additional protection to pulpal tissues. These reactions involve dentin and pulp, both in the initiation of the processes and in their resolution. These responses of the dental pulp to irritation of dentin demonstrate the dynamic nature of the pulpo-dentin complex.

Key words. Dentin, pulp, collagen, odontoblasts, nerves, pulpal blood flow, inflammation, dentin permeability.

Introduction

The purpose of this review is to integrate a great deal of recent information from a wide variety of fields on how the pulpo-dentin complex responds during non-physiologic conditions. Indeed, it is during pathologic stresses that the full range of biologic responses of the pulp to changes that occur in dentin can be expressed. These are the conditions with which most dental clinicians must contend. It is hoped that insights gained by the study of pulpal pathobiology will provide new therapies that will be of use to dentistry in the future. Previous reviews of the biology and pathobiology of the pulpo-dentin complex were published in 1985 and 1992 (see Bergenholtz *et al.*, 1985; Pashley *et al.*, 1992a). This review will not cover the biochemistry of dentin or the pulp (see Butler, 1995), the molecular biology of tooth development (see Thesleff *et al.*, 1995), dentinogenesis (see Linde and Goldberg, 1993; Linde and Lundgren, 1995), odontoblast differentiation (Ruch *et al.*, 1995), dental innervation (Byers, 1984; Hildebrand *et al.*, 1995), or dentin permeability (Pashley, 1990). These areas have all been recently reviewed in depth and will not be revisited. Rather, this review will cover the physiology of dentin, the mechanical properties of dentin, how dentin structure can be modified for therapy, changes in pulpal innervation in response to exposure of dentin, dentin sensitivity, the inter-relationships among pulpal nerves, dentin, and pulpal inflammation, and the reactions of the pulp to wound healing. These areas will not be reviewed exhaustively. This review attempts to integrate broad areas in general, instead of a specific topic in depth, and will refer frequently to more detailed reviews such as those noted above.

(I) The Concept of the Pulpo-Dentin Complex

The physiologic concept of the "pulp-dentin complex" has recently been challenged as an oversimplication (Goldberg and Lasfargues, 1995). These authors correctly point out that there are a number of differences between the chemistry of dentin and that of pulp. For instance, the collagen matrix of dentin is composed primarily of type I collagen, while that of the pulp contains collagen types I, III, and V, among others. Type III collagen is associated with three-dimensional fibrillar networks, while type IV collagen is found in basement membranes. Since peripheral dentin has no basement membrane, it is not surprising to find that it has no type IV collagen. The distribution of noncollagenous proteins is

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State of the art etch-and-rinse adhesives

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ABSTRACT

Objectives: The aim of this study was to explore the therapeutic opportunities of each step of 3-step etch-and-rinse adhesives. *Methods:* Etch-and-rinse adhesive systems are the oldest of the multi-generation evolution of resin bonding systems. In the 3-step version, they involve acid-etching, priming and application of a separate adhesive. Each step can accomplish multiple goals. Acid-etching, using 32–37% phosphoric acid (pH 0.1–0.4) not only simultaneously etches enamel and dentin, but the low pH kills many residual bacteria. *Results:* Some etchants include anti-microbial compounds such as benzalkonium chloride that also inhibits matrix metalloproteinases (MMPs) in dentin. Primers are usually water and HEMA-rich solutions that ensure complete expansion of the collagen fibril meshwork and wet the collagen with hydrophilic monomers. However, water alone can re-expand dried dentin and can also serve as a vehicle for protease inhibitors or protein cross-linking agents that may increase the durability of resin–dentin bonds. In the future, ethanol or other water-free solvents may serve as dehydrating primers that may also contain antibacterial quaternary ammonium methacrylates to inhibit dentin MMPs and increase the durability of resin–dentin bonds. The complete evaporation of solvents is nearly impossible. *Significance:* Manufacturers may need to optimize solvent concentrations. Solvent-free adhesives can seal resin–dentin interfaces with hydrophobic resins that may also contain fluoride and antimicrobial compounds. Etch-and-rinse adhesives produce higher resin–dentin bonds that are more durable than most 1 and 2-step adhesives. Incorporation of protease inhibitors in etchants and/or cross-linking agents in primers may increase the durability of resin–dentin bonds. The therapeutic potential of etch-and-rinse adhesives has yet to be fully exploited.

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Effect of Acid-etching on the Enamel Bond of Two Self-etching Systems

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Ricardo Walter[a]/Patricia N. R. Pereira[c]

Purpose: To evaluate enamel bond strengths of self-etching primer systems with and without the use of phosphoric acid etching.

Materials and Methods: The enamel of sixteen bovine incisors was ground with wet 600-grit SiC paper, and specimens were divided into seven groups. Group SE and group ABF were bonded with Clearfil SE Bond (Kuraray) and an experimental self-etching primer system ABF (Kuraray) in accordance with the manufacturer's instructions. The enamel of groups SE+AC and ABF+AC was acid-etched (AC) prior to application of the primers. The enamel of groups AC+SE-P and AC+ABF-P was acid-etched and the bonding resin was applied without primer. All of these groups were restored with Clearfil AP-X (Kuraray). For the control group (SB), enamel was etched and bonded with Single Bond (3M) according to manufacturer's instructions and restored with Z-250 (3M). After 24 h of water storage, the teeth were sectioned into 0.7-mm-thick slabs, trimmed for microtensile bond testing and subjected to tensile forces at a crosshead speed of 1 mm/min. After testing, all samples were analyzed with SEM. Data were evaluated by one-way ANOVA and Fisher's PLSD ($\alpha = 0.05$).

Results: Acid etching prior to application of the self-etching primer produced higher bond strengths to enamel than self-etching priming only. Omission of the primer step provided bond strengths similar to the other acid-etched groups. SEM analysis revealed that when the acid was applied prior to the self-etching primers, an increase in failure within enamel occurred.

Conclusion: Since high bond strength to enamel is critical for good margins and seal of the restorations, applying the etching step should be considered in case of restorations that rely mainly on enamel bonding.

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Acid etching of enamel has become a reliable technique since it was introduced by Buonocore in 1955.[1] Since then, several types of resin bonding systems have been developed. The first generation of adhesive systems treated the enamel surface, but was able to achieve only 2 to 3 MPa.[11] While second- and third-generation products were still deficient regarding bond strengths, the fourth generation – which consisted of applying a priming agent and adhesive after acid etching the surface – increased the micromechanical retention and bond strengths of adhesive systems to the tooth substrate.[12] Although the bond strengths were satisfactory, simplified adhesive systems were developed in order to reduce the number of steps during the bonding procedure. At the present time, there are essentially two simplified approaches to surface treatments: the all-in-one system, where the

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Review

Immediate dentin sealing for indirect bonded restorations

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ABSTRACT

Purpose: The aim of this article is to review available literature on the clinical procedure of immediate dentine sealing for indirect bonded restorations.

Study selection: More than 40 articles reporting the technique, studies, outcomes, etc. were reviewed after PUBMED/MEDLINE search, most of them addressing the specific situation of dentin bonding for indirect restorations.

Results: It is known that tooth preparation for indirect bonded restorations can result in significant dentin exposures. Immediate application and polymerization of the dentin bonding agent to the freshly cut dentin, prior to impression making is therefore recommended by some authors. Literature indicates that this procedure, *immediate dentine sealing (IDS)*, appears to achieve improved bond strength, fewer gap formations, decreased bacterial leakage, and reduces post-cementation sensitivity. This rational approach to adhesion is also reported to have a positive influence on tooth structure preservation, patient comfort, and long term survival of indirect bonded restorations.

Conclusion: In the extensive literature regarding advantages of using IDS technique significant differences have been shown when compared to Delayed Dentine Sealing. Although more research is required in this field, presently there are NO scientific reasons not to recommend IDS in routine practice.

Contents

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Research Article

Influence of Immediate Dentin Sealing on the Shear Bond Strength of Pressed Ceramic Luted to Dentin with Self-Etch Resin Cement

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Objectives. To examine the effect of immediate dentin sealing (IDS), with dentin bonding agents (DBAs) applied to freshly cut dentin, on the shear bond strength of etched pressed ceramic luted to dentin with RelyX Unicem (RXU) cement. *Method*. Eighty extracted noncarious third molars were ground flat to expose the occlusal dentin surfaces. The teeth were randomly allocated to five groups (A to E) of sixteen teeth each. Groups A to D were allocated a dentin bonding agent (Optibond FL, One Coat Bond, Single Bond, or Go!) that was applied to the dentin surface to mimic the clinical procedure of IDS. These specimen groups then had etched glass ceramic discs (Authentic) luted to the sealed dentin surface using RXU. Group E (control) had etched glass ceramic discs luted to the dentin surface (without a dentin bonding agent) using RXU following the manufacturer's instructions. All specimens were stored for one week in distilled water at room temperature and then shear stressed at a constant cross-head speed of 1 mm per minute until failure. Statistical analysis was performed by ANOVA followed by post hoc Tukey HSD method ($P < 0.05$) applied for multiple paired comparisons. *Results*. The shear bond strength results for group A to E ranged from 6.94 ± 1.53 to 10.03 ± 3.50 MPa. One-way ANOVA demonstrated a difference ($P < 0.05$) between the groups tested and the Tukey HSD demonstrated a significant ($P < 0.05$) difference between the shear bond strength (SBS) of Optibond FL (Group A) and Go! (Group D). There was no statistical difference ($P > 0.05$) in the SBS between the test groups (A–D) or the control (group E). *Conclusion*. IDS using the dentin bonding agents tested does not statistically ($P > 0.05$) affect the shear bond strength of etched pressed ceramic luted to dentin with RXU when compared to the control.

1. Introduction

The preparation of teeth for indirect bonded restorations involves the cutting of dentin and hence the exposure of dentinal tubules [1]. This, in turn, may result in pulpal injury or produce sensitivity [2]. More conservative approaches to restorative dentistry have been made possible by the advent of adhesive technology which also enables sealing of these exposed dentin tubules [3]. It is possible to seal these freshly cut dentin surfaces with a dentin bonding agent immediately after tooth preparation, before impression taking. Most studies on the bond strength of dentin bonding agents use freshly prepared dentin. In daily practice, teeth require provisional restorations to protect the dentin and provide for the patient's functional and aesthetic needs when providing indirect restorations. However, dentin contaminated with provisional cement can reduce the potential for dentin bonding [4].

Magne [5] has described a procedure called immediate dentin sealing (IDS) where a DBA, Optibond FL, is applied immediately after tooth preparation. This is in contrast to the common practice of delayed dentin sealing (DDS) where dentin bonding is carried out just prior to cementation of the definitive restoration. The claimed benefits include minimizing pulp irritation and less need for anesthesia on removal of the provisional crown, as well as an increase in bond strength. This latter finding following final cementation is in agreement with the work of Cherkasski and Wilson [6].

Dental bonding allows the use of resin-based luting cements in conjunction with dentin bonding agents. These

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Effects of Immediate Dentin Sealing and Pulpal Pressure on Resin Cement Bond Strength and Nanoleakage

VB Santana • RS de Alexandre • JA Rodriques
C Ely • AF Reis

Clinical Relevance

The immediate dentin sealing technique was able to prevent negative effects of pulpal pressure on interfaces produced by self-adhesive and conventional multistep resin cements.

SUMMARY

Objective: The object of this study was to evaluate the simulated pulpal pressure (SPP) and immediate dentin sealing technique (IDS) effects on the microtensile bond strength (μTBS) and nanoleakage of interfaces produced by different luting agents.

Methods and Materials: Two self-adhesive luting agents (RelyX Unicem [UC] and Clearfil SA Luting [SA]) and two conventional luting agents (Rely X ARC [RX] and Panavia F [PF]) were evaluated. Eighty human molars were divided in four groups according to luting agents. Each group was subdivided according to SPP (with or without) and dentin sealing (immediate or delayed) using Clearfil SE Bond (n=5). After IDS was performed, specimens were stored in water for seven days before luting procedures. Composite blocks were luted according to the manufacturers' instructions. One half of the specimens were subjected to 15 cm H_2O of hydrostatic pressure for 24 hours before cementation procedures and continued for 24 hours afterward. Then, restored teeth were sectioned into beams and tested in tension. Two additional teeth per group were prepared for nanoleakage evaluation with scanning electron microscopy. Bond strength data were statistically analyzed by three-way analysis of variance and Tukey test.

Results: μTBS of RX decreased when it was subjected to SPP without IDS. However, in the same conditions, μTBS of UC increased. The IDS prevented negative influence of SPP on μTBS of RX and PF; however, a decrease in

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Effect of Resin Coating on Dentin Bonding of Resin Cement in Class II Cavities

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This study was designed to evaluate the efficacy of resin coating on the regional microtensile bond strength (MTBS) of a resin cement to the dentin walls of Class II cavities. Twenty mesio-occlusal cavities were prepared in human molars. In 10 cavities, a resin coating consisting of a self-etching primer bonding system, Clearfil SE Bond, and a low-viscosity microfilled resin, Protect Liner F, was applied. The other 10 teeth served as a non-coating group. After impression taking and temporization, they were kept in water for one day. Composite inlays were then cemented with a dual-cure resin cement, Panavia F 2.0, and stored in water for one day. Thereafter, MTBSs were measured. Two-way ANOVA ($p=0.05$) revealed that the MTBS of resin cement to dentin was influenced by resin coating, but not by regional difference. In conclusion, application of a resin coating to the dentin surface significantly improved the MTBS in indirect restorations.

Keywords: Regional bond strength, Indirect restoration, Dual-cure resin cement

INTRODUCTION

The indirect fabrication of composites is widely used not only for the esthetic treatment of posterior and anterior teeth, but also to conserve tooth structure in the case of large defects. Direct composite restorations are preferred to indirect composite restorations because they require only minimal intervention during cavity preparation — even in posterior restorations[1]. However, polymerization shrinkage of direct composites under confined conditions generates stress at the tooth-restoration interface, which may lead to gap formation, postoperative sensitivity, and secondary caries[2]. Unfortunately, current resin cements do not always provide good bonding performance to dentin compared with dentin bonding systems for direct resin composites[3].

To overcome the lackluster bonding performance to dentin, a resin coating technique was developed in the early 1990s. In this technique, a hybrid layer and a tight sealing film are produced on the dentin surface with a dentin bonding system and a low-viscosity microfilled resin[3-5]. It enables coverage and protection of the prepared dentin immediately after cavity preparation. Therefore, this technique has the potential to minimize pulp irritation and postoperative sensitivity[6,7]. Further, a resin coating can provide a resin cement with high dentin bond strength[3-5,8] and good interfacial adaptation of composite inlays[9]. Therefore, the resin coating technique is a key to achieving minimal intervention with indirect resin composites[10].

Dentin moisture, as well as regional difference, are important factors that may affect dentin bonding[11,12]. The bond strength of the cavity floor dentin of Class I[13,14] and Class II[15] restorations have been evaluated in direct composite restorations. There have also been some studies on the relationship between resin coating and resin cement bond strength[3,8,16-18]. However, there is little information on the regional bond strength of resin cement to resin-coated dentin. Therefore, the purpose of this study was to evaluate the efficacy of a resin coating on the regional (*i.e.*, occlusal and proximal) microtensile bond strength (MTBS) of a resin cement to the dentin walls of Class II (MO) cavities.

MATERIALS AND METHODS

Specimen preparation

Specimen preparation is illustrated in Fig. 1. Twenty non-carious human third molars were used for this study. Mesio-occlusal (MO) cavities with slightly rounded internal line angles were prepared using a regular-grit diamond bur (207CR, Shofu, Kyoto, Japan), and cavity surfaces were finished with a superfine diamond bur (SF 207 CR, Shofu) mounted in an air turbine handpiece under water coolant. Dimensions of the occlusal cavities were approximately 4 mm wide and 2.5 mm high. The mesial gingival margin of the proximal cavity was located 1.5 mm above the cementoenamel junction. Height of the proximal cavities depended on the crown height.

The prepared teeth were randomly divided into two groups. For one group, the cavities were coated

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Review

Protection and Reinforcement of Tooth Structures by Dental Coating Materials

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Abstract: It has been proposed that a resin coating can serve as a means to protect dental structure after preparation of the tooth for indirect restorations, sealing the exposed dentin. The resin coating is applied on the cut surfaces immediately after tooth preparation and before making an impression by assembling a dentin bonding system and a flowable composite. Resin coatings minimize pulp irritation and improve the bond strength between a resin cement and tooth when bonding the restoration to tooth. Recently, thin-film coating dental materials based on all-in-one adhesive technology were introduced for resin coating of indirect restorations. The thin coating materials are applied in a single clinical step and create a barrier-like film layer on the prepared dentin. The thin coatings play an important role in protecting the dentin from physical, chemical, and biological irritation. In addition, these thin-film coating materials reportedly prevent marginal leakage beneath inlays or crown restorations. In light of the many benefits provided by such a protective layer, these all-in-one adhesive materials may therefore also have the potential to cover exposed root dentin surfaces and prevent caries formation. In this paper, recent progress of the dental coating materials and their clinical applications are reviewed.

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ORIGINAL ARTICLE

A prospective 8-year follow-up of posterior resin composite restorations in permanent teeth of children and adolescents in Public Dental Health Service: reasons for replacement

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Abstract
Objectives The aim of the study was to investigate reasons for replacement and repair of posterior resin composite (RC) restorations placed in permanent teeth of children and adolescents attending Public Dental Health Service in Denmark.
Material and method All posterior RC placed consecutively by 115 dentists over a period of 4 years were evaluated at baseline and up to 8 years later. The endpoint of each restoration was defined when repair or replacement was performed. The influence of patient, dentist and material factors on reasons for repair or replacement was investigated.
Results A total of 4,355 restorations were placed. Replacements comprised 406 and repairs 125 restorations. The cumulative survival rate at 8 years was 84 %. Failed restorations were most frequently seen due to secondary caries (57 %), post-operative sensitivity (POS) (10 %) and RC fracture (6 %). POS was observed in 1.5 % of the evaluations and reported more often in girls and from teeth restored with a base material. Older dentists showed lower proportion of replaced restorations due to secondary caries than younger dentists.
Conclusion Posterior RC restorations in children and adolescents performed in general practice showed a good durability with annual failure rates of 2 %. The main reason for failure was secondary caries followed by post-operative sensitivity and resin composite fracture. A high proportion of replaced/repaired RC restorations were caused by primary caries in a non-filled surface.
Clinical relevance Secondary caries was the main reason for failure of RC in children and young adults. More teeth with post-operative sensitivity and a shorter longevity of restorations were observed when a base material was used.

Keywords Children · Clinical · Longevity · Posterior · Resin composite · Restorations

Jette Halken is deceased.

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Introduction

Replacement of failed restorations is still the most common procedure in general dentistry, accounting for a larger proportion of restorative treatments in adults than primary caries, and represents enormous economic expenses each year [1–3]. Due to the environmental concern of mercury, claimed toxicity of amalgam and the increased demand for aesthetic restorations, resin composite (RC) has replaced amalgam increasingly in many countries [1, 4, 5]. As the share of amalgam was continuously decreasing and many dentists had not received basic education in posterior RC therapy during their dental education, it is necessary to know what impact this may have on placement and reasons for replacement of posterior RC restorations. Restorations diagnosed as failed will in most cases be replaced. Some diagnoses of failures are easy and objective, while other, more subjectively estimated reasons, such as bulk or marginal discoloration and secondary caries, have been disputed [6, 7].

The evidence of recording reasons for replacement and longevity depends on the accuracy of the operator in keeping the records after treatment [8]. Unfortunately, recording the reasons for failure is not mandatory in many countries, and

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State of the art of self-etch adhesives

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Enamel

ABSTRACT

This paper reflects on the state of the art of self-etch adhesives anno 2010. After presenting the general characteristics of self-etch adhesives, the major shortcomings of the most simple-to-use one-step (self-etch) adhesives are addressed. Special attention is devoted to the AD-concept and the benefit of chemical interfacial interaction with regard to bond durability. Finally, issues like the potential interference of surface smear and the more challenging bond to enamel for 'mild' self-etch adhesives are discussed.

1. Introduction

Adhesive technology has evolved rapidly since it was introduced more than fifty years ago. The main challenge for dental adhesives is to provide an equally effective bond to two hard tissues of different nature. Bonding to enamel has been proven to be durable. Bonding to dentin is far more intricate and can apparently only be achieved when more complicated and time-consuming application procedures are followed. Consequently, today's adhesives are often regarded as technique-sensitive with the smallest error in the clinical application procedure being penalized either by rapid debonding or early marginal degradation. As a consequence, the demand for simpler, more user-friendly and less technique-sensitive adhesives remains high, urging manufacturers into developing new adhesives at a rapid pace.

Today's adhesives either follow an 'etch-and-rinse' or a 'self-etch' (or 'etch-and-dry') approach, which differ significantly in the manner they deal with tooth tissue. Nevertheless, it should be stated that both approaches have performed successfully in laboratory as well as clinical research, while obviously there also exists a high product-dependency. Following the previous presentation (and paper) by David Pashley on *'The state of the art of etch-and-rinse adhesives'*, the main objective of this presentation (and paper) is to present the latest developments with regard to the self-etch approach.

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RESEARCH AND EDUCATION

Effect of interim cement application on bond strength between resin cements and dentin: Immediate and delayed dentin sealing

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ABSTRACT

Statement of problem. Despite the advances in materials and techniques, adhesion to dentin is challenging because of the complex composition of dentin's mineral, organic, and fluid phases.

Purpose. The purpose of this in vitro study was to evaluate the bond strength of 2 different resin cements (conventional and self-adhesive) with or without previous dentin sealing and the effect of interim cement.

Material and methods. Forty-five molars were embedded into acrylic resin blocks and a flat dentin surface was exposed. Twenty teeth (n=5 per group) were treated with the conventional resin cement associated with etch-and-rinse or self-etch adhesive approaches, applied before (immediate dentin sealing) or after (delayed dentin sealing) the application/removal of interim cement. Another 25 teeth (n=5, per group) were treated with self-adhesive resin cement with (self-etch mode [immediate dentin sealing or delayed dentin sealing]) or without adhesive application. Furthermore, in the self-adhesive resin cement group, the application of polyacrylic acid for dentin etching before cementation was evaluated. Composite resin blocks were cemented onto flat, treated dentin surfaces, and the assemblies were sectioned into bar-shaped specimens for microtensile bond strength testing. The data were subjected to 1-way ANOVA followed by the post-hoc Tukey test (α=.05). The failure patterns were classified as cohesive, adhesive, or mixed.

Results. The application of adhesive before interim cement (immediate dental sealing) promoted the highest values of bond strength for both resin cements (P<.001). For self-adhesive resin cement, polyacrylic acid-enhanced bond strength after the application of interim cement.

Conclusions. The application of dental adhesive immediately after tooth preparation (immediate dentin sealing) and before the use of an interim cement promoted the highest values of bond strength to dentin with the resin cements tested. (J Prosthet Dent 2016;■:■-■)

Since the advent of adhesive dentistry, the composition of the materials and the clinical methods used for adhesion has changed.[1] Several studies have evaluated different adhesive materials and techniques, and the results of these reports are fairly consistent.[2-6] However, adhesion to dentin is challenging because of the complex composition of dentin's mineral, organic, and fluid phases.[4,7]

The conventional bonding technique includes a 3-step etch, prime, and bond protocol followed by conventional resin cement. These systems are reported to achieve the highest bond strength values.[4] The superior bonding may be attributed to optimal dentin hybridization and the formation of a complete hybrid layer. The adhesive infiltrates into the collagen fibrils, forming a biocomposite;[8] therefore, the resin matrix is reinforced by these fibrils. These adhesives have achieved consistently good bond strength values in in vitro tests.[4,7-9] However, in clinical practice, techniques with

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An effect of immediate dentin sealing on the shear bond strength of resin cement to porcelain restoration

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PURPOSE. The aim of this study was to determine differences in shear bond strength to human dentin using immediate dentin sealing (IDS) technique compared to delayed dentin sealing (DDS). **MATERIALS AND METHODS.** Forty extracted human molars were divided into 4 groups with 10 teeth each. The control group was light-cured after application of dentin bonding agent (Excite® DSC) and cemented with Variolink® II resin cement. IDS/SE (immediate dentin sealing, Clearfil™ SE Bond) and IDS/SB (immediate dentin sealing, AdapterTM Single Bond 2) were light-cured after application of dentin bonding agent (Clearfil™ SE Bond and Adapter™ Sing Bond 2, respectively), whereas DDS specimens were not treated with any dentin bonding agent. Specimens were cemented with Variolink® II resin cement. Dentin bonding agent (Excite® DSC) was left unpolymerized until the application of porcelain restoration. Shear strength was measured using a universal testing machine at a speed of 5 mm/min and evaluated of fracture using an optical microscope. **RESULTS.** The mean shear bond strengths of control group and IDS/SE group were not statistically different from another at 14.86 and 11.18 MPa. Bond strength of IDS/SE group had a significantly higher mean than DDS group (3.14 MPa) ($P < .05$). There were no significance in the mean shear bond strength between IDS/SB (4.11 MPa) and DDS group. Evaluation of failure patterns indicates that most failures in the control group and IDS/SE groups were mixed, whereas failures in the DDS were interfacial. **CONCLUSION.** When preparing teeth for indirect ceramic restoration, IDS with Clearfil™ SE Bond results in improved shear bond strength compared with DDS. **[J Adv Prosthodont 2010;2:39-45]**

KEY WORDS. Immediate dentin sealing, Delayed dentin sealing, Dentin bonding agent, Shear bond strength, Ceramic restoration, Resin cement

INTRODUCTION

In recent years, interests in porcelain restorations such as laminate veneer have increased as people aspire more for esthetics. Conservative tooth preparation is the major advantage of laminate veneer. However, there is a high possibility of dentin exposure when teeth are convex or crowdedly aligned despite of confining to enamel surface in preparation. When dentin is exposed, applying dentin bonding agent (DBA) is necessary for retention of laminate.

In conventional dentin bonding procedure, dentin bonding agent is applied when laminate is seated to tooth in cementation. Clinically, to avoid incomplete seating of the restoration, it is recommended to maintain resin adhesive unpolymerized before laminate veneer is placed.[1,2] The reason is that the thickness of polymerized dentin adhesive varies from 60 - 80 μm to 200 - 300 μm depending on the structure of tooth surfaces, although less than 40 μm thickness is recommended before setting of restoration.[1,3] Additionally, since the thickness of oxygen inhibition layer which plays an important role in bonding with resin reaches up to 40 μm, making dentin adhesive excessively thin may weaken the bond strength between bonding agent and resin.[4] In other words, the thick film could interfere with the complete seating of the restoration when dentin bonding agent is light-cured before placement of laminate veneer.

However, it is reported that curing dentin adhesive and resin cement individually in order showed greater bonding strength than curing both simultaneously.[2,5] This comes from the fact that unpolymerized dentin-resin hybrid layer collapses during the placement of restoration.[1,6]

Therefore, new attempts have been carried out to optimize the application of dentin bonding agent.[1,7,8] The procedure where adhesive is applied right before the impression taking and after tooth preparation is called immediate dentin bonding or immediate dentin sealing (IDS).[9] In addition, to demarcate conventional dentin adhesive system from IDS, it is called delayed dentin sealing (DDS).[9] By carrying out IDS, restorations can be correctly placed because impression is taken after the complete polymerization of the dentin adhesive. It is reported that bonding strength is improved by protecting dentin-resin hybrid layer.[1,7,8,10-12]

Paul and Shärer[8] stated that bonding strength increased

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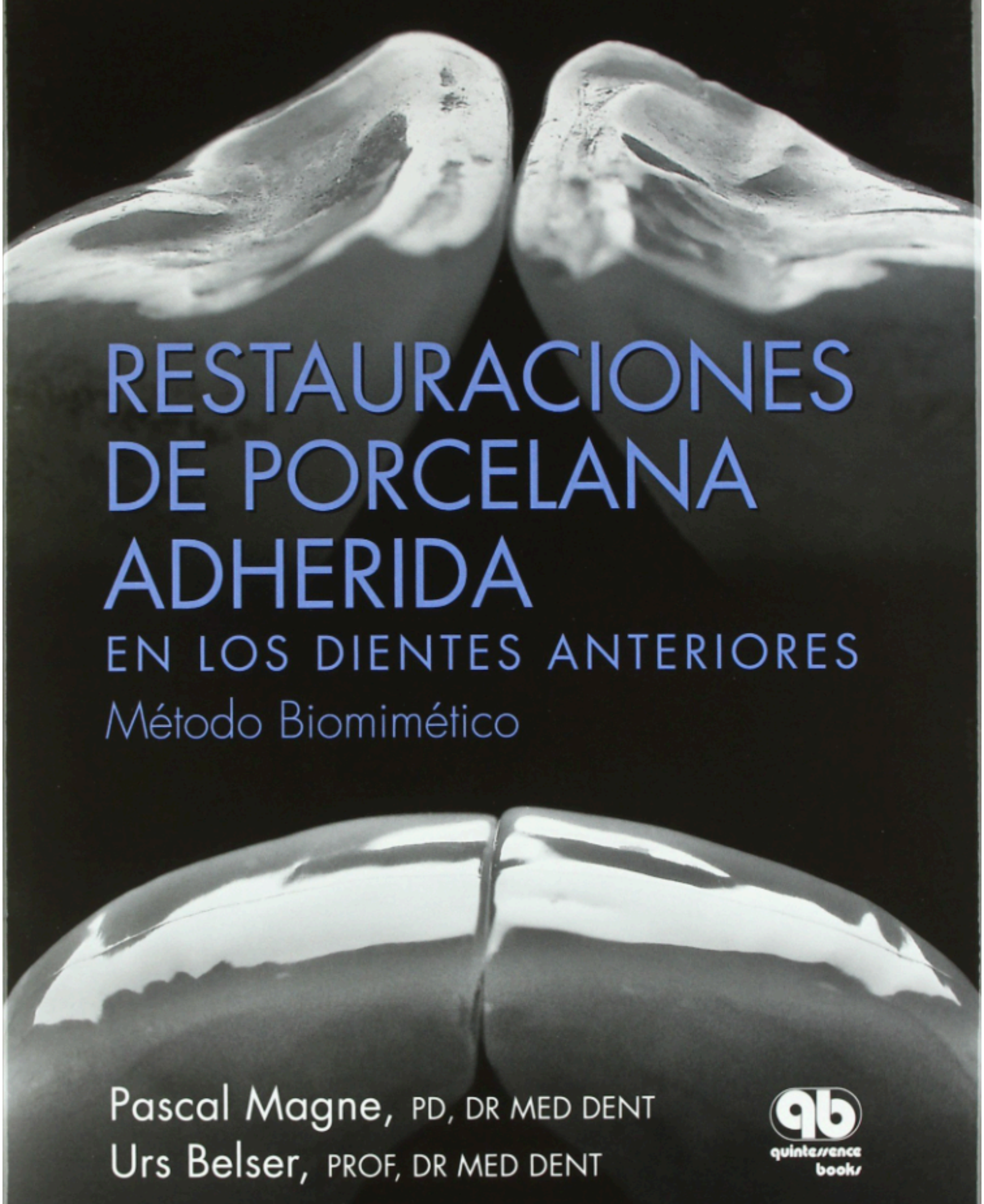
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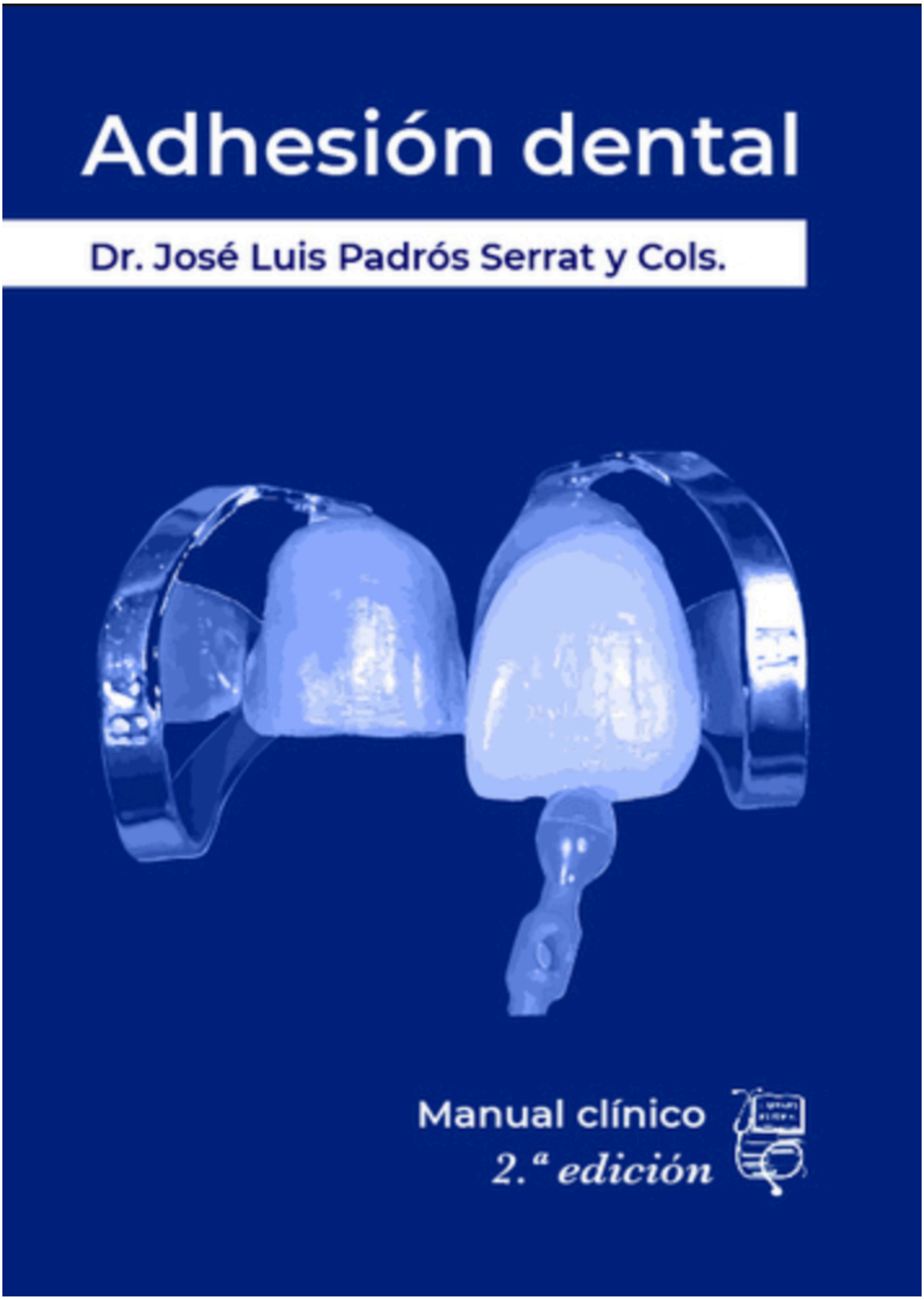
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