Adhesive Preparation Technique: Angles and Aesthetics

By Dr Gary Unterbrink

The original "adhesive" preparation technique as described in the literature was proposed prior to the introduction of effective dentin bonding agents. It had nothing to do with adhesion, but was based primarily on geometry (Luescher). The combination of beveled margins and undercuts utilized shrinkage to improve marginal adaptation, analogous to placing a rivet in steel beam constructions. In fact, the classic "adhesive preparation technique" relied on internal gap formation to improve marginal adaptation, which in turn frequently led to postoperative sensitivity.

While the bond to dentin is important to reduce post-operative sensitivity and the risk of secondary caries at dentin margins, the bond to enamel is much more important to achieve a stable esthetic result. Unfortunately, many aspects of preparation for conventional restorative techniques have simply been transferred to adhesive techniques, without questioning their validity for new materials.

Two interactive factors should be mentioned in relation to preparation technique. Bonding materials have reduced the requirement for mechanical retention. Metal-free restorative systems also open new possibilities: the elimination of metal with its requirement for opaquers contributes to a reduced need for deep preparations, and supragingival margins can be used without aesthetic compromise.

Investigations have shown that margin form and preparation depth do not influence the strength of bonded full ceramic crowns (Meier, Fenske, Bernal, El-Mowafy, Wiskott). Note that conventionally cemented metal-free restorations still require a shoulder. We will come back to crowns later, but begin with some general principles.

Bevels

The literature is ambiguous in relation to bevels on margins, in particular for occlusal surfaces. Clinically, margins are beveled for three main purposes:

- to contribute to retention: increased enamel bond surface area
- to reduce microleakage: bevels more frequently cut across prism ends
- to improve esthetics: softening the transition from tooth to restorative material

It could be noted that the placement of bevels for cast metal restorations is done to help compensate for dimensional variation of impressions and models, but this also fits into to category of reducing microleakage.

The angle of a bevel is important for the etch pattern and bond stability, the depth of a bevel is the primary determinant of strength in relation to retention, and the length of a bevel the most important factor for esthetics. However, we probably should not even use the classic term „bevel" in relation to adhesive dentistry, but would more correctly speak of preparation angles and margin forms.

Bonding to enamel

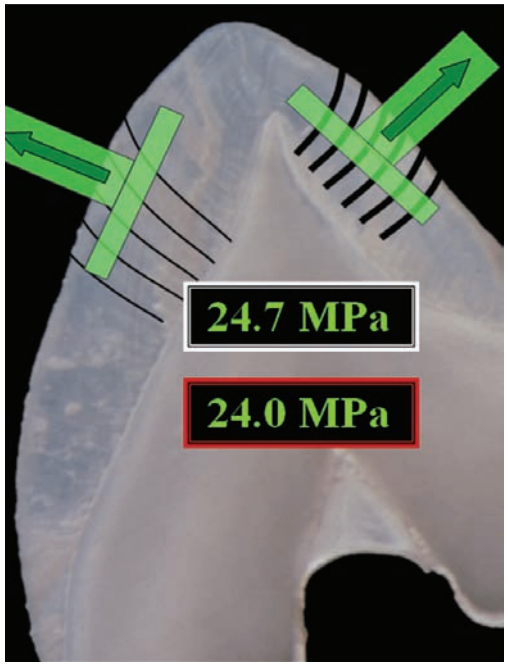
Bonding to enamel is taken for granted; simply etch, rinse, and apply the bonding agent.

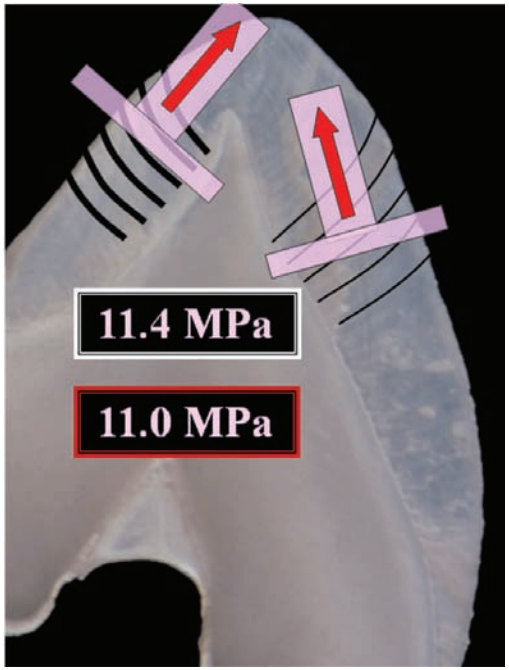
However, if it was really this simple, we would not see so many "adhesive" restorations with discoloured enamel margins. The etching and rinsing times (a number of publications would indicate that an etching time of 30 seconds will reduce variability compared with 15 seconds), the resin application technique (rubbing the etched enamel with a brush can destroy the fragile etch pattern), the contact time (at least 20 seconds should elapse before light polymerization), the influence of the bonding agent primer on enamel bonding (thick layers of hydrophilic primers can lead to problems with bond stability), and the variations of the question "How wet is damp?" can all influence our result.

Nearly all bond strength testing is done under ideal laboratory conditions with the preparation nearly perpendicular to the prism direction. We know that we need to cut across the prisms to get a reliable bond. But what are the correct angles? In most textbooks, enamel prisms are drawn perpendicular to the surface. While this is true for some areas of the teeth, it certainly is not correct as a general rule. Prisms reach the DEJ at approximately 90°.

Here we can see bond strengths measured perpendicular and parallel to the tooth surface (Carvalho, Ikeda). The prism orientation in the areas of the bonding are shown with the black lines. Note that the parallel bonding surfaces do cut the prisms at an almost ideal angle, but the perpendicular samples still cut across some of the prisms due to the curvature of the prism rods. A preparation truly parallel to the prisms can result in a bond strength approaching zero, and the clinical result is a gap and a stained margin. If the preparation undercuts the prisms at the margin, the immediate result is a white margin, which generally stains and fractures over time.

Considering the importance of enamel prism orientation in adhesive dentistry, it is surprising how little attention has been paid to this aspect of preparation technique (Munechika, Rasmussen, Osborne, Pinheiro).





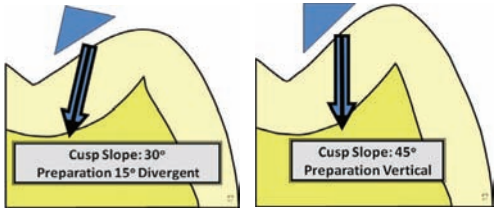
Posterior restorations

Occlusal Margins / Onlays

On the occlusal surface, from the fissure area out to about 1.0 mm from the cusp tips, the prisms at the surface demonstrate an angle of 60-65°, as can be seen in the previous graphic. This is valid for all posterior teeth (Uriba). The correct preparation angle therefore depends on the angle of the cusp slope, a general recommendation for divergence of inlay preparations is therefore not possible. Here in particular the word "bevel" is completely inappropriate.

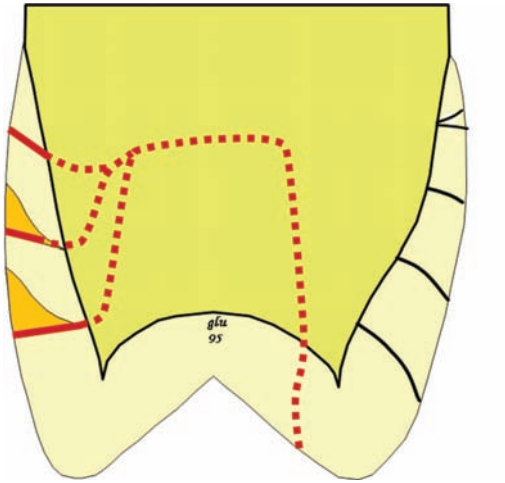
On the occlusal surface, one can use the following idea for orientation. Imagine a right angle to the cusp slope, and try to bisect this angle with the preparation.

Another way to express this (see below) is that one desires a 45° angle in the restoration margin (an angle of 135° in enamel).



On teeth with flat cusps, for example the typical upper second molar, you have to find a compromise between the preparation angle and the extension of the cavity.

The following computer graphic (see next page) represents a "simplified average" for the outer enamel surface on vestibular and oral surfaces, proximal surfaces are very similar.



A preparation at the angle of the red lines will provide a good etching pattern and bond, but blunt margins tend to cause aesthetic difficulties, in the occlusal and middle thirds of the tooth a bevel can be prepared to soften the transition and improve aesthetics. This aesthetic modification is really only required for extremely demanding patients or maxillary premolar buccal cusps.

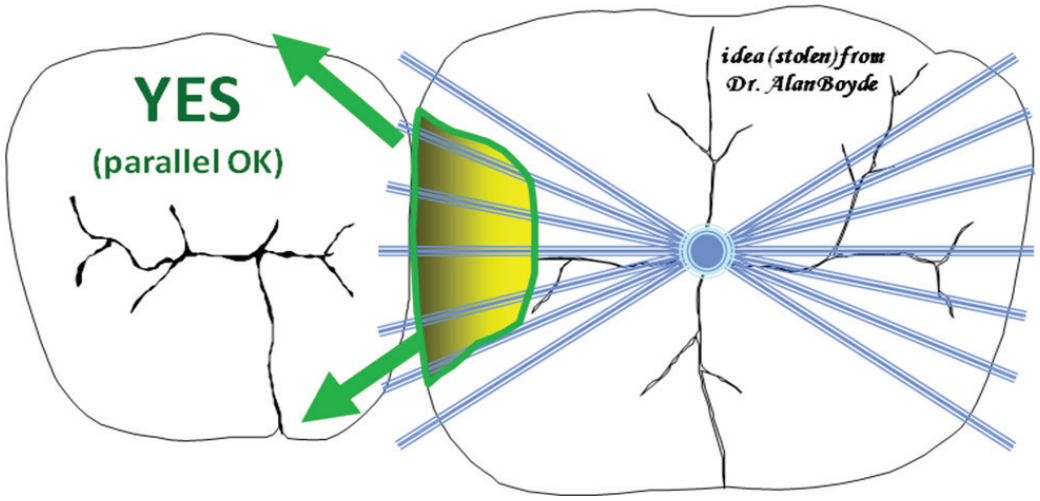
Finish lines on the cusp tips are a problem, since the prisms in this location are nearly vertical. With laboratory fabricated restorations (inlays), as opposed to direct restorations, the chance that these margins will be esthetically stable increases but it is still preferable to avoid any margin at a cusp tip.

The lack of bonding if the preparation is parallel to the prisms is one explanation for the nearly equivalent incidence of cusp fractures with "bonded" composites and amalgam with intracoronal restorations (Wehr).

Clinically, direct composites also show better long term survivability if all thin cusps are onlayed. Clearly more onlays should be prepared for both direct and indirect restorations (Benedicenti, Opdam). In general, the cusp should be reduced approximately 1.5 mm. As the preparation margin moves gingivally, the angle of the preparation is increased.

Gingival margins
Prisms in cervical enamel demonstrate a fairly wide variation, but in general are perpendicular to the surface or angled slightly down. Margins in cervical enamel should be "beveled" to improve the etch pattern (Lutz, Hinoura, Halter, Cheung, Loesche, Opdam).

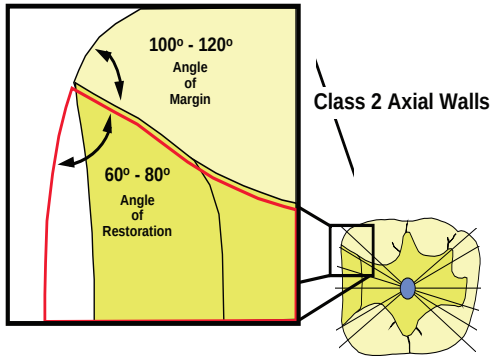
Although I prefer a higher angle with direct restorations, approximately 45°, the dental technicians prefer 20-30° for indirect techniques. Steeper angles make the laboratory work more difficult, especially with ceramic – talk to your technician! A properly fitting inlay also reduces the requirement for an optimal bond, so some compromises are permissable.



Proximal Boxes: Axial Walls
When I look through the models in a typical dental laboratory, this aspect of the preparation is frequently incorrect. The easiest way to imagine the angles of the prisms on these walls is an idea I have adapted from Prof. Alan Boyd of London. Think of a point in the center of the tooth, and lines radiating out from this point. This corresponds reasonably well to the average prism direction. (Note: Decussation is particularly prominent at the transition zone from proximal to lateral surfaces.)

The preparation should cross these lines from the inside to the outside, or at least be parallel to them. With laboratory techniques you have a bit more freedom, since shrinkage stress is minimized.

The following graphic illustrates the "correct" angle, perhaps the easiest way to control this clinically is to remember that the remaining enamel should never be less than 90°, i.e. should never form an acute angle.



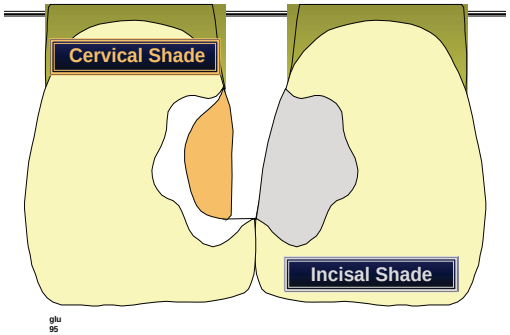
Anterior restorations
The prism orientation with anterior teeth corresponds roughly to individual posterior cusps. The prisms curve strongly toward the incisal

edge in the incisal 1/3, and become approximately perpendicular to the surface at the junction of the middle and cervical thirds.

As with posterior teeth, at the cervical margin the preparation is angled down at 30-45°. If the incisal edge is strong enough with a small to medium Class 3, a horizontal internal preparation permits reverse etching. On the palatal, the vertical margin is "beveled" at about the same angle as the cervical. Labially, long bevels are usually placed to improve esthetics.

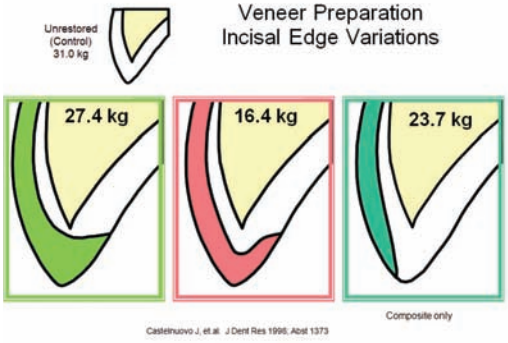
With direct restorations, I prefer to prepare what I call a "wave bevel" on the labial. This is a part of the concept of "aesthetic camoflage", the eye does not see a curved line at the margin as easily as a straight line or smooth curve.

Shade Selection and Restoration



Also here, the long bevel helps compensate for a shade or translucency mismatch by softening the transition between tooth and restoration and extremely thin margins. In a certain sense, a veneer is a very long bevel. Naturally, the preparation technique for laboratory fabricated restorations must avoid undercuts, however, the same ideas are used.

A chamfer on the palatal aspect of anterior veneer preparations is unnecessary and probably contraindicated (Kimura, Castelnuevo, Priest, Smales). It weakens the final restoration and makes the laboratory fabrication more complicated.



Crown preparations
Crowns are the restorations of last resort, and crown preparations should only be performed when more conservative treatment is impossible. Conventional full crowns are perhaps the most overprescribed treatment in dentistry today. Adhesive techniques can provide significant advantages, but traditional treatment modalities seem to be particularly well entrenched in prosthodontics.

Posterior teeth with intact buccal and lingual enamel, and a wall thickness of 2 mm or more at the cervical aspect should not be crowned, an adhesive onlay is the preferable method for restoring these teeth (Krifka).

Anterior teeth which do not demonstrate caries on the palatal surface, i.e. the majority of them, should not be prepared on the palatal to the gingival margin, the palatal margin should be placed on the cingulum (Magne). The following clinical example demonstrates this.

Despite the requirement for endodontic treatment and a glass fiber post on the right central incisor, the palatal margin of the final preparation simply encompasses the endodontic access opening. Extending this preparation to the gingival margin is clearly not necessary for an adhesively cemented restoration.

When crowns are unavoidable, research has also shown that adhesively cemented full ceramic crowns require less axial preparation than conventionally cemented metal-ceramic crowns (Meier, Burke, Kelly). The advantages are clear: the tooth is more fracture resistant cervically and the risk of endodontic complications is reduced (Edelhoff).

All crown preparations require an anatomic reduction, with adhesively cemented full ceramic crowns this can be as little as 0.6 to 0.8 mm., and this is valid for anterior and posterior teeth. An incisal reduction of anterior teeth of 1.5 mm is frequently recommended, although this is

almost never correct. In fact, any standard value for incisal reduction is nonsense, the anatomic axial reduction of the oral and vestibular surfaces, followed by rounding any sharp angles, automatically creates the proper reduction for that particular tooth. (This is incidentally on average 3-4 mm with maxillary anterior teeth.) Straight labial preparations (i.e. non-anatomic) and underpreparation of the incisal edge is an extremely common mistake; leading to overcontoured and often opaque crowns and/or traumatic occlusion.

Here we see the replacement of a metal-ceramic FPD with e-max full ceramic. The main cause of the poor aesthetics was a non-anatomic labial preparation.

Conclusion

Adhesive dentistry is not simply the substitution of bonding agents and composites for traditional dental materials: the optimal preparation techniques differ dramatically in relation to margin position and geometry. In many clinical situations, we can provide restorations which are functionally and aesthetically better than conventional dentistry, bringing us slightly closer to the goal of "nihil nocere".

Literature

1.Benedicenti S, Vovani U, Revera G. A 4-6 year retrospective clinical study of creacked teeth restored with bonded indirect composite onlays. Int J Prosthodont 2007; 20: 609-16

2.Bernal G, Jones RM, Brown DT, Goodacre CJ. The Effect of Finish Line Form and Luting Agent on the Breaking Strength of Dicor Crowns. Int J Prosthodont 1993; 6: 286-290

3.Boyd A. Anatomical considerations relating to tooth preparation. In: International Symposium on Posterior Composite Resin Dental Restorative Materials. Vanherle G, Smith DC eds. Utrecht. Peter Sculc Publishing Co. 1985: 377-403

4.Burke FJT. Fracture resistance of teeth restored with dentin bonded crowns, the effect of increased tooth preparation. Quintessence Int 2006,27(2):115-21

5.Carvalho RM, Santiago SL, Fernandes CAO, Byoung IS, Pashley D. Effects of Prism Orientation on Tensile Strength of Enamel. J Adhesive Dent 2000; 2: 251-257

6.Castelnuevo J, Tjan AHL, Phillips K, Nicholls JI, Kois JC. Fracture Strength and Failure Mode for Different Ceramic Veneer Designs. J Prosthet Dent 2000;83(2):171-80

7.Cheung GSP. A scanning electron microscope investigation on the acid-etched cervical margin of Class II cavities. Quint. Int. 1990; 21:299-302

8.Edelhoff D and Sorensen JA. Tooth structure removal associated with various preparation designs. J Prosthet Dent 2002;87(5):503-9

9.El-Mowafy OM, Fenton AH, Forrester N, Milenkovic M. Retention of metal ceramic crowns cemented with resin cements: Effects of preparation taper and height. J Prosthetic Dent 1996;78:524-529
10.Fenske C, Jarren MP, Sadat-Khonsari HD, Jüde HD. In-vitro-Untersuchung zur Bruchfestigkeit von IPS-Empress-Kronen in Abhängigkeit von der Stufenbreite. Dtsch. Zahnärztl. Z. 1999: 54: 732-734
11.Günther J, Haller B. Zur Optimierung der Randschlussqualität von Kompomerfüllungen in Klasse-II-Kavitäten. DGZ Tagung, 1997: Abstr 156
12.Hadad, R, Hobson RS, McCabe JF. Micro-tensile bond strength to surface and subsurface enamel.
13.Halter TK, Owens BM, Brown DM. Microleakage of Tooth Colored Restorations With a Beveled Gingival Margin. J Dent Res 1997;76:Abstr 409,65
14.Hilton TJ, Ferracane JL. Cavity preparation factors and microleakage of Class II composite restorations filled at intraoral temperature. Am J Dent 1999;12:123-130
15.Hinoura K, Setcos JC, Phillips RW. Cavity design and placement techniques for class 2 composites. Operative Dentistry 1988; 13: 12-19
16.Hofmann N, Klaiber B, Haller B, Haghi M, Hausmann P. Interproximal margin quality of class II resin restorations in vitro. J Dent Res 1995 (Special Issue):Abstr 151
17.Ikeda T, Uno S, Tanaka T, Kawakami S, Komatsu H, Sano H. Relation of enamel prism orientation to microtensile bond strength. Am J Dent. 2002 Apr;15(2):109-13
18.Kimura T, Yamaguchi R, Katoh Y. Study on Fracture Resistance of Porcelain Laminate Veneer Restorations. J Dent Res 1997;76:Abstr 1436,193
19.Krell KV, Rivera EM. A six year evaluation of creaced teeth diagnosed with reversible pulpitis, treatment and prognosis. J ENdod 2007: 33: 1405-7
20.Krifka S, Anthofer T, Fritzsch M, Hiller KA, Shmalz G, Federlin M. Ceramic inlays and partial ceramic crowns: influence of remaining cusp wall thickness on the marginal integrity and enamel crack formation. Oper Dent 2009; 34(1): 32-42
21.Loesche GM, Neuerburg CM, Roulet JF. Die adhäsive Versorgung konservativer Klasse-II-Kavitäten. Dtsch Zahnärtz Z 48: 1993: 26-31
22.Luescher B, Lutz F, Ochsenbein J, Muehlemann HR. Microleakage and marginal adaptation in conventional and adhesive Class 2 restorations. J Prosthet Dent 1977; 37: 300-309
23.Lutz F, Imfeld T, Barbakow F, Iselin W. Optimizing the marginal adaptation of MOD composite restorations. Suzuki M, Jordan RE, Boksman L. Posterior composite resin restorations -- clinical considerations. Both in: International Symposium on Posterior Composite Resin Dental Restorative Materials. Vanherle G, Smith DC eds. Utrecht. Peter Sculc Publishing Co. 1985; 405-419
24.Magne P, Douglas H. Design optimization and evolution of bonded ceramics for the anterior dentition. Quintessence Int 1999; 30: 661-72
25.Meier M, Fischer H, Richter EJ, Maier HR, Spiekermann H. Einfluss unterschiedlicher Präparationsgeometrien auf die Bruchfestigkeit vollkeramischer Molarenkronen. Dtsch Zahnärtzl Z 1995; 50: 295-299
26.Munechika T, Suzuki K, Nishiyama M, Ohashi M, Horie K. A Comparison of the Tensile Bond Strengths of Composite Resins to Longitudinal and Transverse Sections of Enamel Prisms in Human Teeth. J Dent Res 1984;63:1079-1082
27.Opdam NJA, Rooters JJM, Loomans BAC, Bronkhorst EM. Seven year Clinical Evaluation of Painful Cracked Teeth Restored with a Direct Composite Restoration. J Endod 2008; 34: 808-11.
28.Opdam NJM, Roeters JJM, Kuijs R, Burgersdijk RCW. Necessity of bevels for box only Class II composite restorations. J Prosthet Dent 1998; 80: 274-279
29.Osborn JW. Directions and Interrelationships of Enamel Prisms From the Sides of Human Teeth. J Dent Res 1968;47(2):223-231
30.Osborn JW. Evaluation of Previous Assessments of Prism Directions in Human Enamel. J Dent Res 1968;47(2):217-222
31.Pinheiro Fernandes C, Chevitarese O. The orientation and direction of rods in dental enamel. J Prosthet Dent 1991;65:793-800
32.Priest G. Proximal margin modifications for all-ceramic veneers. Prac Proced Aesthet Dent 2004;16:275-82
33.Rasmussen ST, Patchin RE, Scott DB, Heuer AH. Fracture Properties of Human Enamel and Dentin. J Dent Res 1976;55:154-164
34.Schuckar M, Guertsen W. Proximo-cervical adaptation of Class-II composite restorations after thermocycling. J Dent Res 1996;73 (Special Issue);Abstr 183:40
35.Smales RJ, Etemadi S. Long term survival of ceramic veneers using two preparation designs. Int J Prosthodont 2004;17:324-6
36.Uribe Echevarria J, Priotto Elba G, de Uribe Echevarria N. Angulacion de las vertientes cuspideas internas en relacion con las estructura adamantina y los tallados cavitarios para amalgama. Avances en Odontoestomatologia 1988; 4(4): 200-208
37.Wiskott HWA, Nicholls JI, Belser UC. The Effect of Tooth Preparation Height and Diameter on the Resistance of Complete Crowns to Fatigue Loading. Int J Prosthodont 1997; 10: 207-215.
38.Xu HHK, Kelly JR, Johanmir S, Thompson VP, Rekow ED. Enamel Subsurface Damage Due to Tooth Preparation with Diamonds. J Dent Res 1997; 76(10): 1698-706

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