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The "Myth" of Nanoleakage

Dear Reader,

It was Dr. Hidehiko Sano (Hokkaido University, Japan) who described in 1995 for the first time the phenomenon of nanoleakage.[5,6] He introduced the term nanoleakage "to describe the diffusion of small ions or molecules within the hybrid layer in the absence of gap formation". Dr. Sano used silver nitrate as a tracer to disclose the open nanometer-sized pathways within the hybrid layer (Fig 1). Since his discovery, much research has been devoted to this phenomenon, basically because it is recognized as one of the factors, if not the most important one,[2] that leads to degradation of the bond to dental tissue. Water sorption has not only a plastification effect; in the long term, it may also result in hydrolysis of the interface constituents, mainly of the adhesive monomers. However, the unprotected dentinal collagen may also hydrolize with time. This diffusion-dependent degradation mechanism is most likely the major reason for today's limited lifetime of adhesive restorations. More recent research has revealed that fluids are not only absorbed from the outer oral environment, but also from the host tooth (Fig 1).[1,7] Increasing the hydrophobicity of adhesives is one of the strategies for making adhesive interfaces more resistant to hydrolytic degradation,[3] which today is apparently only realizable using a multistep approach.[9]

Besides SEM, the most common technique for assessing nanoleakage is TEM.[8] It should be very clear that nearly all commercial adhesives, significantly also including the so-called gold-standard three-step etch-and-rinse adhesives (Fig 1), have repeatedly been documented with a certain degree of silver deposition within, underneath, and/or above the hybrid layer (Fig 2). It should also be stressed that the degree of silver deposition and the occurrence pattern (often referred to as "spot" or "reticular" type) always varied considerably with the region, even within the same TEM section (Fig 3). As the silver infiltration is naturally diffusion dependent, factors like the time the samples have been exposed to the silver nitrate, the size of the specimens (or length of the diffusion path), the nature and depth of dentin, etc, have a significant effect on the occurrence/appearance of nanoleakage.

This is actually not that surprising, considering that dentin is extremely porous and thus very permeable. Besides the dentinal tubule structure, intertubular dentin is indeed constructed of a mineralized collagen network that is full of nanometer-sized pores (note the tiny electron-lucent holes within the unaffected dentin in Figs 1 to 3).

Just as the "classical" microleakage assessment is controversial, imaging of nanoleakage using both SEM and TEM should be interpreted with extreme care. The high regional variability makes it very difficult to obtain representative information with regard to the resistance of the adhesive against nanoleakage. Using TEM, one should realize that only very small areas are analyzed, again limiting the repre-

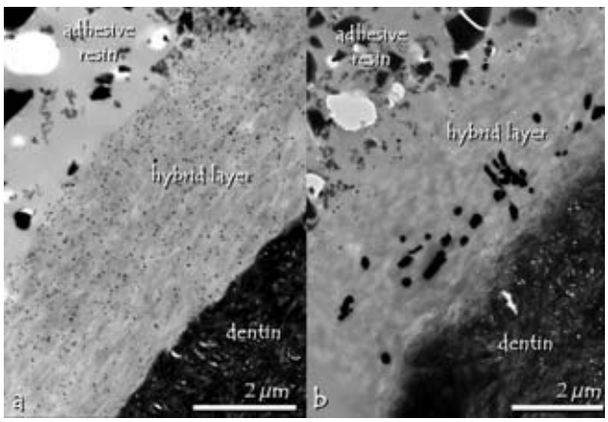

Fig 1 TEM photomicrograph illustrating the deposition of silver within the hybrid layer produced by a "gold-standard" three-step etch-and-rinse adhesive, when (a) the silver nitrate solution was supplied to the opened pulp chamber or (b) when the whole tooth was immersed in silver nitrate for 24 h.

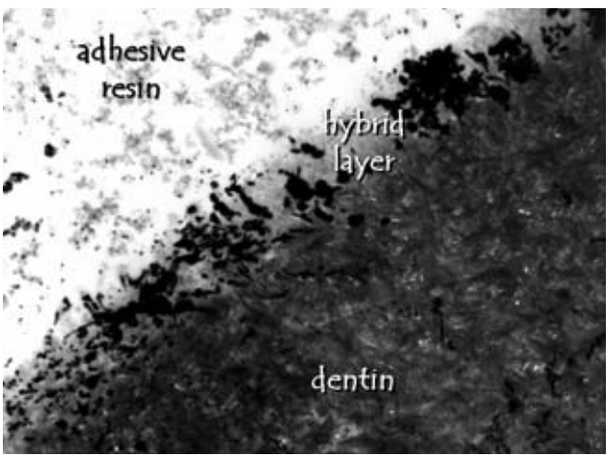

Fig 2 TEM photomicrograph illustrating the deposition of silver within the hybrid layer produced by a "gold-standard" mild two-step self-etching adhesive; silver deposition also within the adhesive layer and the highly porous "unaffected" underlying dentin.

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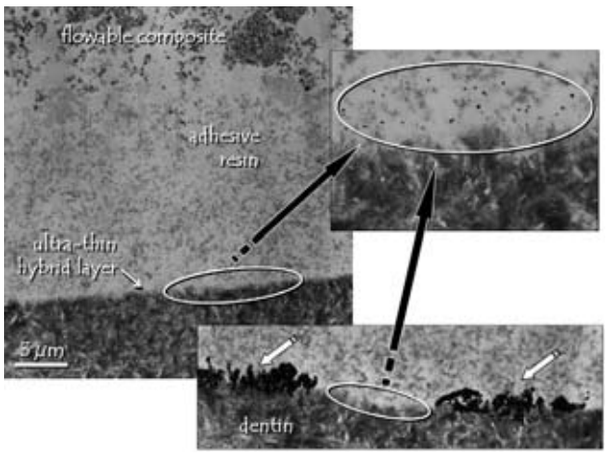

Fig 3 TEM photomicrograph illustrating the high regional variability of silver deposition at the interface between a mild one-step self-etching adhesive and dentin.

sentativeness of the data obtained, unless a sufficient number of sections originating from a sufficient number of teeth are imaged and thoroughly quantitatively analyzed. Again, even the so-called gold-standard adhesives today appear incapable of preventing nanoleakage, though clinical research has undoubtedly proven excellent clinical long-term performance.[4]

On the whole, all adhesives appear to leak at least to a certain degree and at certain areas, and it is difficult to interpret its relevance for the subsequent clinical performance. For leakage (nano- as well as microleakage) to be a valuable criterion for evaluating adhesive performance, it should therefore be fully quantitatively determined in three rather than two dimensions.

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