

Atraumatic restorative treatment (ART) – factors affecting success

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Abstract

The success of tooth restorations rendered according to principles of the Atraumatic Restorative Treatment (ART) approach is dependent on various clinical factors. The most common failures, due to these factors, are partial material loss; complete material loss; caries related to restoration margin and material wear >0.5 mm. The main reason for clinical ART failures are related to operator skills and performance. The prevention and management of ART failures includes emphasis on correct clinical indication and the repair of failed restorations. A new caries classification may provide guidance for clinical indication. The classification combines site and size of a lesion, which is reflected in a dual coding system. In addition, ART training and diligence during ART application are important for clinical success. First published in *J Appl Oral Sci* 2006; 14:34-6.

The success of tooth restorations rendered according to principles of the Atraumatic Restorative Treatment (ART) approach is dependent on various clinical factors. The most common failures, due to these factors, are:

- Partial material loss
- Complete material loss
- Caries related to restoration margin
- Material wear >0.5 mm

In contrast to other ART failures, the occurrence of failures related to recurrent caries has steadily decreased due to improvements in restorative materials and operator skills¹. ART failures may occur in combination or lead to each other, e.g. material loss may promote occurrence of secondary caries, or partial defects may lead to complete loss of the restorative material over time.

During caries progression beyond the enamel-dentin junction, dentine is first exposed to bacterial acids resulting in extensive demineralization of peritubular dentine and partial mineral loss of intertubular dentine. This early exposure is followed by bacterial invasion, together with the denaturation of dentinal collagen by proteolytic enzymes. As result carious dentine can be divided into affected dentine (a partially demineralized thus harder inner layer, containing only few bacteria) and infected dentine (a largely dematerialized, thus much softer denatured outer layer). The outer layer contains the majority of bacteria. In addition, the complete loss of odontoblast

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processes in this layer, caused by proteolysis, renders this layer non-sensitive². Hand excavation, as a mechanical form of selective caries removal, is capable to remove most of the infected dentin. However, research showed that bacteria remain present after complete hand excavation within the tubuli of affected dentine³. The potential caries risk due to the remaining bacteria can be successfully controlled by reducing bacteria activity and through remineralisation. Caries activity can be reduced through effective nutrient deprivation by sealing the cavity using filling materials which chemically bond to the cavity walls and which assist remineralisation of affected dentine through long-time fluoride and mineral release⁴. The current materials of choice are high strength glass ionomer cements (GIC)¹. Hence, a loss of GIC filling material would also result in the loss of caries-arresting factors. Therefore, a good chemical bond between material and tooth tissue appears to be important for the success of ART restorations.

Clinical factors responsible for ART failures are

1. Material Factor
2. Operator Factor
3. Technique Factor

Material factor

Material factors are directly related to material (GIC) properties, such as physical strength, flow rate and Material consistency. With the development of newer high strength glass ionomer cements, physical properties have been improved. However, the strength of GIC remains inferior to traditional restorative materials, particularly amalgam and composite resin. The flow rate of GIC is directly related to the adaptability to the cavity surface. Improved GIC flow rate may reduce void formation. In addition, small

void formation (diameter < 0.1 mm) within the restoration, may depend on the type of material mix, capsule or hand mix. Hand mix is operator depended and thus may incorporate more air entrapments than capsule mixing. A large number of voids may weaken the material and make it prone to higher wear and material loss on restoration margins⁵.

Operator factors

Operator factors relate to failures caused by insufficient operator performance, particularly in the areas of incorrect clinical indication, caries removal, moisture control, cavity conditioning, material mixing (hand mix) and material insertion¹. Operator decisions leading to incorrect application of ART under clinical conditions not favourable for ART may result in a too large restoration, with constant exposure to masticatory forces, exceeding GIC strength. In combination with limited physical strength of GIC (material factor) this may lead to restoration fracture and subsequent loss of restorative material. Insufficient removal of infected dentine, particularly on the cavity circumference may cause a reduced chemical bond between tooth tissue and material, higher residual bacteria count and the access of those bacteria to substrates via occurring leakage with subsequent further caries progression.

Insufficient cavity conditioning, as well as saliva contamination of the prepared cavity through insufficient moisture control supports the retaining of a smear layer attached to tooth tissue. Such smear layer compromises the chemical bonding process of GIC to the cavity walls. Weak bond strength causes an increased likelihood of material loss. In contrast, the reduction of the smear layer through effective dentine conditioning using a 10% poly acrylic acid (PAA) for 10-

15 seconds improves the bond strength between material and tooth tissue. The correct material consistency is vital for effective material retention and physical strength. A too dry mixture has limited bond strength, a too moist mixture reduced resistance to wear and compressive strength. Furthermore, GIC needs to be inserted into the cavity in increments and condensed. Incorrect insertion and /or condensation will cause air entrapments, causing reduced physical strength of the restoration².

A study, measuring operator performance in relation to the level of void avoidance, showed that initial training is needed. It was also shown that after training, experience levels are less important than operator diligence during the ART procedure^{5,6}.

Hand excavation and press finger technique are both components, unique to clinical ART protocol¹. Hand excavation causes enamel fracturing and irregularities in dentine. Both manifest as challenges to a good marginal GIC adaptation, important for effective bond strength of the material to the cavity walls. In addition, press finger technique causes a rough restoration surface with irregular margins, supporting potential plaque and bacteria retention. However, self-smoothing occlusal forces and the antibacterial action of GIC may counter act such negative effect⁶.

Failure prevention and management

The prevention and management of ART failures includes emphasize on correct clinical indication and the repair of failed restorations. A new caries classification may provide guidance for clinical indication. The classification combines site and size

of a lesion, which is reflected in a dual coding system and expressed in the form of a grid (Table 1)^{7,8}.

Table 1. New caries classification / Summary of classes

Site/Size	0	1	2	3	4
1	1.0	1.1	1.2	1.3	1.4
2	2.0	2.1	2.2	2.3	2.4
3	3.0	3.1	3.2	3.3	3.4

The classification of sites follows the three surface areas on which caries occurs:

- Site 1: pits & fissures (occlusal and other smooth tooth surfaces)
- Site 2: contact area between 2 adjacent teeth
- Site 3: cervical area in contact with gingival tissues

The classification of size follows four stages of the carious lesion:

- Size 0: carious lesion without cavitation and can be remineralized
- Size 1: small cavitation- just beyond healing through remineralisation
- Size 2: moderate cavity not extended to cusps
- Size 3: Enlarged cavity, with at least one cusp which is undermined and which needs protection from occlusal load
- Size 4: Extensive cavity, with at least one cusp or incisal edge which is lost

Clinical studies on the success rates of ART fillings show a higher success related to one surface restoration, without any occlusal or proximal contact with antagonistic or neighbouring teeth (Site 1 / Size 1 and 2), particularly in the permanent dentition¹.

The management of ART failures follows principles of restoration repair instead of replacement¹. Table 2 provides an overview how to repair failed ART restorations.

Table 2. ART failure management

ART failure	Management
Partial material loss	Cleaning fracture surface, Application of dentine conditioner Placement of new GIC layer
Complete material loss	Cleaning cavity surface, Application of dentine conditioner Placement of new GIC layer
Caries related to restoration margin	Caries removal using hand excavator Cleaning GIC surface Application of dentine conditioner Placement of new GIC layer

Conclusion

The main reason for clinical ART failures are related to operator skills and performance (operator factor). Against this background, ART training and diligence during ART application are important for clinical success.

摘要

根据防损填充性疗法(ART)的原理而带来的牙洞修补成功,依赖于各种临床因素。由于这些因素而招致的最常见的失败是部分材料脱落、全部材料脱落、与修补边缘及材料磨损>0.5mm有关的龋患。临床ART失败的主要原因与操作者的技术和实施表现有关。

防止及管理ART失败,包括强调正确的临床症候指示及填充失败的修理。一种新的龋齿分类可以为临床症候指示提供引导。

该分类结合了牙损的位置和大小,用一个双码系统反映。

此外,ART训练和ART应用中的勤勉对于临床成功至关重要。首次发表于*J Appl Oral Sci* 2006; 14: 34-6。

Resumen

El éxito de las restauraciones dentales, realizadas en concordancia con los principios planteados por la técnica de Tratamiento Restaurador Atraumático (ART), depende de diversos factores clínicos. Las fallas más comunes debido a estos factores, son la pérdida parcial o total de material, caries relacionadas al margen de restauración y desgaste de material >0.5mm. La razón principal por la que ocurren las fallas clínicas del ART, está relacionada a las habilidades y desempeño del operador. La prevención y manejo de las fallas del ART, incluye el énfasis en una correcta indicación clínica y la reparación de restauraciones fallidas. Una nueva clasificación de las caries, puede proveer de una guía para la indicación clínica. La clasificación combina la ubicación y el tamaño de la lesión, lo que se refleja en un sistema de codificación dual. Además, para obtener el éxito clínico, son importantes el entrenamiento en el ART y diligencia durante su aplicación. Publicado primero en *J Appl Oral Sci* 2006; 14:34-6.

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