©Operative Dentistry, 2016, **Supplement 7,** S27-S34

From 'Direct Versus Indirect' Toward an Integrated Restorative Concept in the Posterior Dentition

NJM Opdam • R Frankenberger • P Magne

Clinical Relevance

The decision whether a required dental restoration should be direct or indirect is made daily in clinical practice. Guidelines for this decision are presented.

SUMMARY

Traditionally, indirect restorations are expected to have better longevity than direct restorations. The introduction of adhesive dentistry and the minimally invasive approach of restorative treatment has changed this. In this article, the differences in longevity between direct and indirect restorations in the posterior dentition are explained. In addition, the advantages and disadvantages of direct and indirect restorations placed in a minimally invasive way and using a proper adhesive technique are described.

*Niek J. M. Opdam, PhD, DDS, Radboud Institute for Molecular Life Sciences, Department of Dentistry, Radboud university medical center, Nijmegen, The Netherlands

Roland Frankenberger, DMD, PhD, Chair, Department of Operative Dentistry and Endodontics, Philipps University of Marburg and University Hospital Giessen and Marburg, Campus Marburg, Marburg, Germany

Pascal Magne, D.M.D., M.Sc., Ph.D, The Don and Sybil Harrington Professor of Esthetic Dentistry, Herman Ostrow School of Dentistry of USC, Division of Restorative Sciences

*Corresponding author: PO Box 9101, Nijmegen, NL 6500 HB, Netherlands; e-mail: niek.opdam@radboudumc.nl

DOI: 10.2341/15-126-LIT

INTRODUCTION

Numerous dental restorations are placed each day in human teeth, mainly to restore defects caused by caries but also those caused by tooth wear (mechanical and erosive) and fracture.[1] In addition, because dental restorations have limited longevity, a significant part of restorative work by dentists includes replacing defective existing restorations.[2,3]

Basically, restoration replacement results in a restorative cycle of defective restorations being replaced by larger restorations that will someday fail again, which will lead to even larger restorations, possible root canal therapy, more risk for complications, and eventually tooth loss. This restorative cycle of death of the tooth was described by Elderton[4] in 1988 and Simonsen[5] in 1991. To reduce and maybe even interrupt this restorative cycle, which could possibly lead to prolonged tooth retention, different approaches must be considered:

- Postpone the first restoration as long as possible by using advanced diagnostic methods and caries detection techniques.
- Use less aggressive excavation and caries removal methods to maintain pulp vitality.

Table 1: *Review Articles on the Longevity of Dental Restorations*

Restoration Type	AFR	Authors	Year	Journal	Research Type
Direct restorations					
Amalgam	3%	Manhart and Hickel	2004	Operative Dentistry	Review
Amalgam	1%	Heintze and Rousson	2012	Journal of Adhesive Dentistry	Meta-analysis
Posterior composite	1%	Heintze and Rousson	2012	Journal of Adhesive Dentistry	Meta-analysis
Posterior composite	2%	Opdam and others	2014	Journal of Adhesive Dentistry	Meta-analysis
Glass-ionomer cement	7%	Manhart and Hickel	2004	Operative Dentistry	Review
Indirect restorations: inlays					
Inlay-composite	3%	Manhart and Hickel	2004	Operative Dentistry	Review
Inlay-gold	1%	Manhart and Hickel	2004	Operative Dentistry	Review
Inlay-ceramic	2%	Manhart and Hickel	2004	Operative Dentistry	Review
Ceramic CAD/CAM	2%	Manhart and Hickel	2004	Operative Dentistry	Review
Ceramic CAD/CAM	2%	Wittneben and others	2009	International Journal of Prosthodontics	Systematic review
Ceramic-CEREC	1%	Fasbinder	2006	Journal of the Canadian Dental Association	Review
Indirect restorations: crowns					
IPS Empress crowns	1%	Heintze and Rousson	2010	International Journal of Prosthodontics	Systematic review
All-ceramic crown	2%	Pjetursson	2007	Clinical Oral Implants Research	Systematic review
Metal-ceramic crown	1%	Pjetursson	2007	Clinical Oral Implants Research	Systematic review
All-ceramic FPD	2%	Sailer and others	2008	Clinical Oral Implants Research	Systematic review
Metal-ceramic FPD	1%	Sailer and others	2008	Clinical Oral Implants Research	Systematic review
Zirconia crowns: tooth supported	1%	Larsson and Wennerberg	2014	International Journal of Prosthodontics	Systematic review
Zirconia crowns: implant supported	1%	Larsson and Wennerberg	2014	International Journal of Prosthodontics	Systematic review

Abbreviations: AFR, annual failure rate; CAD/CAM, computer-aided design/computer-aided manufacturing; FPD, fixed partial denture.

- Reduce the amount of tooth substance loss by using minimally invasive preparation and restorative techniques.
- Improve the restoration seal, bonding, and overall quality for longer restoration survival
- Use a more conservative approach toward restoration replacement and maintenance by postponing, repairing, or refurbishing rather than always replacing completely.

Historically, indirect restorations, especially crowns, were considered long-lasting restorations, and the aim was for the restoration to be permanent. However, almost no restoration is really permanent, except the last one in a patient's lifetime. Traditionally, in a tooth that will be restored with an indirect restoration, all direct restorative materials are removed or are covered by the indirect restoration in an attempt to promote the restoration's longevity. This is mainly based on the assumption that an indirect restoration will have a better marginal fit and that indirect restorative materials are more resistant to deterioration over time due to wear, fracture, and discoloration. These traditional restorative concepts may be obsolete for two reasons:

1. Even though differences are noted *in vitro*, the clinical longevity of modern adhesive restorative materials, whether placed directly or indirectly or under ideal and less than ideal circumstances, does not differ significantly (Table 1).
2. Under less than ideal circumstances, certain risk factors may be present that are not related to the quality of the restorations or the different properties of direct and indirect restorations. These risk factors, such as high caries risk or bruxism, may impair restoration and tooth longevity independent from the type of material.[6,7]

For too long, the longevity of the restoration itself has been the focus of the attention. Today, it appears that it is more important to preserve the underlying tooth and the functioning of the dentition as a whole. In a good restorative concept, it is important to keep open future options for restorations as the present available restoration will fail in the future and will need replacement, repair, or adjustment. This is the essence of the biomimetics approach,[8] in which the aim is not to create the strongest restoration but rather a restoration that is compatible with the mechanical, biologic, and optical properties of underlying tissues. This article will discuss recent developments in restorative dentistry that aim to preserve a well-functioning dentition during a lifetime.

LONGEVITY OF RESTORATIONS

Clinical data on the longevity of dental restorations are widely available but have to be interpreted with caution. Prospective clinical trials are considered the best option to measure the longevity of dental restorations. Several systematic reviews based on prospective clinical trials have been published and Table 1 shows the results for several types of restorations. It is remarkable that direct composite restorations, indirect ceramic and composite restorations, and crowns of several designs do not differ that much in annual failure rates, which vary between 1% and 2%, according to recent review articles.[1,9–16] These studies conclude that indirect restorations, especially crowns, do not have better longevity.

A few drawbacks to these studies need to be mentioned. First, restorations in prospective clinical studies are mostly placed by calibrated operators in a university setting, which leads to optimal restorations that possibly last longer than those placed under real-life routine conditions in a general practice setting.[17] Second, patient selection for prospective studies likely includes motivated patients without such problems as high caries risk or bruxism, factors that are known to have a negative effect on the longevity of dental restorations.[6,7,18,19]

Therefore, it can be expected that a lower survival of restorations will be found in a general dental practice environment. Data are available from cross-sectional studies,[2,20–22] but this study design has been shown to grossly underestimate restoration longevity and results in findings of higher longevity for older materials. Thus, past conclusions that longevity of restorations in dental practices was as low as 3 years (median) for composites and 5 years for amalgam[21] are not justified as these calculations are based on these deceptive data for failed restorations.[23]

Data from longitudinal studies on longevity of dental restorations in a general practice environment are limited, and most are related to specific dentists[6,7,24] or public health dental care.[25–27] From these practice-based studies, annual failure rates of 1%-3% for composites have been found dependent on several factors, and these data are comparable to the outcomes of university studies. From an insurance database in the United Kingdom, 10-year survival rates of crowns have been reported to be 48% for porcelain fused to metal and 68% for full metal crowns.[28]

Therefore, it can be concluded that longevity data are no longer a justification for making a choice between direct and indirect restorations and between resin composite, metal, or ceramic materials.

SIZE OF THE DEFECT

Traditionally, small defects in teeth are treated with a direct restoration. For larger defects, including cusp replacement and deep cervical outline, different restorative options are available, either direct or indirect:

1. For large posterior and anterior defects, a direct composite restoration can be a feasible solution. Several studies have shown that a direct composite is suitable for restoration of large defects, including cusp replacement, and for treating cracked teeth,[6,29–33] The skills of the operator, who should be able to deliver an adequate restoration with appropriate morphology as well as proximal and intermaxillary contacts, seem to be the predominant limiting factor.
2. Inlay/onlay restorations are also considered to be an option for larger defects. They have the advantage of precision and better control on the final morphology and occlusion. However, the need for a tapered preparation design may result in increased tooth tissue loss. This can be prevented by using immediate dentin sealing[34,35] and direct composite buildups to remove undercuts. Inlay/onlay restorations fit in a modern restorative concept; however, technique sensitivity and demands for the operator are not reduced compared with direct restorations.
3. For a long time, crowns were considered the best restorations for severely compromised teeth. Disadvantages of crowns are that they require sufficient ferrule and that the outline should be extended considerably toward the cervical region which may result in loss of more tooth substance. The costs for crowns are considerable; therefore, some restorative dentists recommend alternative concepts.[36] Furthermore, traditional crown preparations cut many sound areas that have never been attacked by caries. This primarily means that the probability of endodontic complications is significantly increased compared with more defect-oriented preparations.
4. Indirect restoration with elevated margins.

When an indirect restoration is placed, typically all existing restorations are replaced or covered with the indirect restoration, which results in a considerable amount of tooth substance loss when trying to

achieve a divergent preparation design without undercuts, especially when a full crown is placed. A restorative technique has been introduced to deal with the problem that indirect adhesive inlays are difficult to cement without rubber dam or matrix *in situ* to protect the area from contamination when a deep subgingival proximal outline is present.[37–39] With this restorative concept, called deep margin elevation, the outline of the indirect restoration is elevated to the supragingival level.

There are other clinical approaches to this dilemma. Deep gingival margins can be exposed by surgical apical displacement of the supporting bone and gingiva. This may, however, compromise the attachment level and generate possible anatomical complications such as the proximity of root concavities and furcations. Once exposed to the oral environment, those areas can be problematic to maintain and may generate other complications. In the more conservative deep margin elevation technique, a base of composite resin is used to elevate the subgingival proximal margins underneath direct or indirect bonded restorations (Figures 1 through 3). The procedure, also called coronal margin relocation, is performed under rubber dam isolation with the placement of a matrix. In addition to the supragingival elevation of the margin, immediate dentin sealing and an adhesive composite resin base are used to reinforce undermined cusps, fill undercuts, and provide the necessary geometry for the inlay/onlay restoration.

ADHESION WITH LARGER RESTORATIONS

Traditionally, metal-based crowns are luted with glass-ionomers, zinc-carboxylate, or zinc-phosphate cement, materials that are somewhat forgiving in a relatively moist environment. The newer all-ceramic concepts require adhesive cementation based on composite bonding technology, as the preparations are less retentive, and optimal bonding of the restoration to the tooth is demanded.

A possible problem arising with cementing full ceramic crowns with a subgingival margin is how to maintain a dry working field for the adhesive procedure. In operative dentistry, moisture control is often obtained with a rubber dam, but this is not the only option. Use of cotton rolls and suction as well as special devices, such as an isolation mouthpiece (Isolite Systems, Santa Barbara, CA, USA) and a proper matrix and wedge as applied with direct restorations, offer good moisture control even with subgingival restorations. For subgingival indirect restorations, placement of a wedge and matrix is difficult as it would compromise the fit of the restoration. Therefore, unless margins are clearly relocated supragingivally, placement of a rubber dam can be done but probably will not prevent contamination from the sulcus and hence an indirect, subgingivally placed adhesive restoration seems to be a lucky shot when it comes to the quality of the marginal fit.

The previously described deep margin elevation technique could provide a solution for this problem as the first subgingival part of a large restoration could be placed using a specially designed matrix (Figures 1-3), enabling the best possible moisture control. Thereafter, a rubber dam could be placed easily and a (supragingival) direct or indirect restoration could be placed adhesively without too many problems.

THE ULTIMATE CHALLENGE: PATIENTS WITH SEVERE EROSION AND TOOTH WEAR

The ultimate challenge for restorative treatment is a patient who suffers from severe tooth wear, especially one who is still relatively young. The main etiologic factors of severe tooth wear, including loss of vertical dimension, are erosion and bruxism. In particular, heavy bruxism can cause deterioration of teeth and dental restorations. For these patients the strongest restorations are required, but at the same time it has to be recognized that these restorations will have to be replaced in the future. Therefore, a treatment that mostly includes an increased vertical dimension would be minimally invasive and at the same time offer fracture-resistant restorations. Even wear/erosion accompanied by difficult anterior occlusal relationships (deep Class II or edge to edge) can be resolved in a minimally invasive way through occlusal therapy using the centric relation and the Dahl principle.[40] Indirect restorations that need sacrifice of a substantial amount of tooth substance are therefore not the first choice, although in these patients crowns are often still recommended. Clinical studies of restorations in patients with severe tooth wear are limited and include only a few studies with direct composites,[31,33,41] and those resulted in different levels of success. Several case reports have been published on minimally invasive indirect techniques using computer-aided design/computer-aided manufacturing (CAD/CAM) tabletop restorations or semidirect treatments using a mold intraorally and or using ceramic restricted to labial veneers.[42–44]

Posterior composites seem to be the most successful materials offering the most fracture-resistant

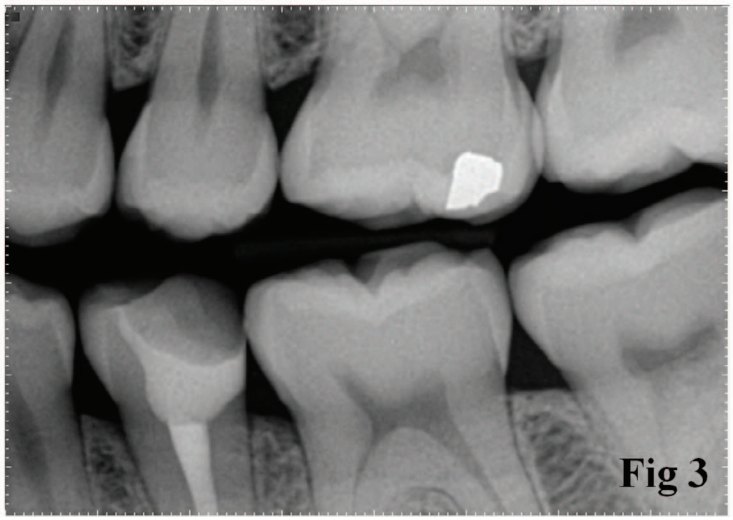

Figure 1. *Clinical case indicated for the deep margin elevation technique.*

Figure 2. *Super-curved matrix modified for elevation.*

Figure 3. *Post-elevation bitewing radiograph.*

restorations in cases of bruxism. *In vitro* studies confirm these results when fracture resistance of composites and ceramics bonded to dentin are tested. If this is the case, and clinical results should be obtained especially for indirect ceramic restorations in treating patients with tooth wear, then the question is why indirect restorations should be made if the purpose is to strengthen the tooth. Full metal restorations possibly have the best properties in this respect but are surely in decline. A recently published randomized clinical trial comparing indirect and direct restorations for premolar teeth with a cusp fracture showed no difference in performance.[32]

CONCLUSIONS AND RECOMMENDATIONS

Traditionally, reasons to choose indirect restorations ranged from indirect restorations are stronger to indirect restorations last longer, the defect is too large for a direct restoration, and subgingival margins in cementum require an indirect restoration. As can be concluded from this article, these reasons are no longer supported in contemporary dentistry. However, there are still some situations in which there are good reasons to choose an indirect over a direct technique, including the following:

- In large rehabilitations in which the dentition has to be restored extensively, indirect techniques allow for preoperative design with wax-up or digital wax-up and better management of occlusion and vertical dimension.
- In cases where optimal form and esthetics are required, indirect techniques have advantages, especially when ceramic materials are used.
- In cases in which a direct restoration is too difficult for the operator to make, sometimes an indirect restoration can be more successful.

Alternatively, direct restorations are more preferred

- When minimally invasive techniques are required, especially in high-risk and young patients.
- When low-cost treatments are the only option.
- When the dentist is skilled in direct techniques; for such operators, direct techniques are indicated in more situations.

In conclusion the following recommendations may be made:

1. Crowns have limited indications, namely, to replace an existing crown, for implant restorations, and occasionally to serve as bridges for abutment teeth. In most other cases less invasive options should be preferred.
2. Indirect or direct techniques should be minimally invasive and adhesive. Modern restorative techniques should include immediate dentin sealing, adhesive bases when required, and deep margin elevation in cases where indirect restorations have to be made.
3. The operator's skill in direct techniques is an important factor. Training in large direct composites should be part of the dental training program.
4. Indirect techniques should aim for predictable full mouth rehabilitations, as reconstructions can be supported by a preoperative diagnostic buildup/wax-up made by the dental technician or the dentist. CAD/CAM techniques might become increasingly important for these techniques.
5. For a subgingival outline the deep margin elevation technique may be the best option for indirect restorations. This technique can also be useful when placing deep and large direct restorations.
6. Ceramics offer the best esthetic properties, but because of their mechanical properties, they should be limited to the esthetic zone, especially for patients with bruxism.

Regulatory Statement

This work was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the College of Dental Sciences, Radboud University Medical Centre, in the Netherlands.

Conflict of Interest

The authors have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

(Accepted 1 May 2015)

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