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Criteria for the Replacement of Restorations: Academy of Operative Dentistry European Section

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Clinical Relevance

Restoration replacement is considered to be a last resort, subsequent to excluding the preventively oriented, minimum intervention alternatives of monitoring, refurbishment, and repair.

SUMMARY

The replacement of a restoration is one of the most common procedures in dentistry. However, the criteria for such intervention, excluding catastrophic failure and persistent discomfort and pain, continue to be the subject of considerable debate. The decision-making process remains subjective on the part of the treating clinician, while the evidence base for

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refurbishment and repair rather than replacement for the management of defective and failing restorations continues to grow and strengthen. This article, prepared as an Academy of Operative Dentistry European Section consensus publication, reviews existing criteria for the replacement of restorations and encourages practitioners to shift, if not already doing so, to considering the replacement of a restoration as a last resort rather than as a prudent action to be taken if in any doubt about clinical acceptability. Further research in the area, spanning the risk assessment of defective and failing restorations and new diagnostic tools and processes, together with work to enhance the evidence base of restoration repair *vs* replacement, would be of immense value.

INTRODUCTION

The replacement of a restoration is one of the most common procedures in the clinical practice of dentistry; globally, the annual cost of this activity runs to many millions of euros.[1] It is estimated that as many as 56% of restorations placed by dentists are replacements of existing restorations rather than the treatment of new lesions of caries.[2] The decision of when and how to act in relation to a restoration that has been identified as having a defect that may lead to failure remains problematic given ongoing debate and an ever-expanding evidence base on criteria for intervention. Subjectivity on the part of the operator, influenced by many different confounding factors, has an important influence. An illustrative example of this can be seen from UK and US settings where patients who change dentists are more likely to experience restoration replacement than those who do not.[3-5]

This suggests that practitioners tend to "wait and watch" deteriorating restorations in patients with whom they are familiar, while practitioners who have not seen a patient previously are either more critical of the work of others or more risk averse and tend to intervene to avoid possible future criticism. Alternatively, patients who change dentist for a variety of reasons, such as loss of confidence in their previous dentist, may be reluctant to accept a "wait and watch" approach and request that any suspect restorations be replaced, believing this to be in their best interests. As a result, two distinct patterns of care may be observed in primary care dentistry, one for regular attending patients with stable oral health and another for new patients. Whatever the pattern of care, the best interests of the patient will not be best served by unnecessary intervention.

Criteria for intervention in deteriorating restorations (excluding catastrophic failure, persistent discomfort and pain) and the need to consider applying an alternative restorative approach (Figure 1), continue to be controversial and are changing as the evidence base for refurbishment and repair rather than replacement for the management of defective and failing restorations continues to grow and strengthen.[6] While there are a number of studies that support restoration repair,[7-9] Cochrane systematic reviews in this area have concluded only that there is an absence of relevant high-quality evidence.[10,11] That said, restoration repair offers many advantages when compared to restoration replacement, not least a minimal intervention approach to treatment as well as prolonging restoration longevity.

Reasons for the replacement of asymptomatic direct intracoronal restorations include secondary caries (caries adjacent to restorations [CAR]), fracture, and, for tooth-colored restorations, discoloration, with relatively little variation in frequency of these reasons, regardless of, among other factors, restorative material, geographic location, the different populations of patients, and the experience of clinicians.[2] Reasons for the replacement of indirect intra- and extracoronal restorations have not been studied to the same extent as the reasons for the replacement of direct restorations, but, as with direct restorations, the primary reason for replacement is secondary caries, as diagnosed clinically.[12] The concern arises as to what is and what constitutes secondary caries as diagnosed clinically; this has been shown to vary widely within and between different groups of clinicians, leading to variability in decision making on the sufficiency of restorations in clinical service.[12] This extends to individual clinicians, their familiarity with the patient, and the restorations being examined and depends on the technique and special tests and investigations used to make the diagnostic decisions.[3,4,14] For example, clinicians have been shown to be less likely to replace restorations they placed.[3,4] The use of magnifying aids may also significantly influence decisions to accept or replace restorations.[13] Is the cause of such variability the use of inappropriate criteria, inconsistent application of the criteria, or a consequence of the complex, multifactorial nature of decision making in the assessment of the sufficiency of restorations in clinical service? It is suggested that all three of these factors play a part in the variability

Figure 1: *A case in which the replacement of defective and failing restorations may be indicated to adopt an alternative restorative approach.*

of decision making observed in the everyday practice of operative dentistry. This variability is cause for concern to, in particular, patients, patient consumer groups, and third-party funders of dental care.

This article, prepared as an Academy of Operative Dentistry European Section consensus publication, reviews the development and use of different criteria for the replacement of restorations and explores the ways in which widely applied criteria are changing as the evidence base for refurbishment and repair as an alternative to replacement influences the fate of defective and failing restorations.

CVAR AND RYGE

In an attempt to address the limited availability of data concerning the service life and clinical performance of restorations, a team lead by Dr Gunnar Ryge in 1964 set about the seemingly impossible task of devising a system to quantify the clinical performance of dental restorative materials. Seven years later, Cvar and Ryge published their much-cited paper on criteria for the clinical evaluation of dental restorative materials.[15] This paper was reprinted in 2005, together with a historical note compiled by Bayne and Schmalz.[16] These criteria, generally referred to as the US Public Health Service (USPHS) criteria, not only have had a remarkable impact on clinical dental research[16] but also provide certain criteria for the failure of (need to replace) restorations—the so-called Charlie ratings. These ratings include the following:

- Color match: The mismatch between restoration and adjacent tooth structure is outside the normal range of tooth color, shade, and/or translucency.
- Cavosurface marginal discoloration: Discoloration has penetrated along the margin of the restorative material in a pulpal direction.
- Anatomic form: Sufficient restorative material is missing so as to expose the dentin or base.
- Marginal adaptation: The restoration is mobile, fractured, or missing in part or *in toto*.
- Caries: There is evidence of caries contiguous with the margins of the restoration.

In the late 1970s and 1980s, individuals involved in the clinical evaluation of restorative materials extended ("modified") the so-called USPHS criteria to include assessments of other features of restorations, with the additional criteria including further Charlie ratings. For example, in the clinical trial of Occlusin (ICI Dental, Macclesfield, UK), the largest, multicenter clinical trial of a restorative material ever undertaken, a Charlie rating was included in the methodology for temperature sensitivity, that is, sensitivity to temperature change, typically postoperative sensitivity, extending over a period of more than 2 weeks, considered to be an indication to replace the restoration.[17]

FDI WORLD DENTAL FEDERATION

In 2007/2008, new clinical criteria for the evaluation of direct and indirect restorations were approved by the FDI World Dental Federation and simultaneously announced in three dental journals.[18-20] The criteria were categorized into three groups of parameters: esthetic (four criteria), functional (six criteria), and biological (six criteria). Each criterion could be expressed by one of five scores: three for acceptable and two for nonacceptable (one for repairable and one for replacement). Experience in the use of these criteria led to a number of modifications. In 2010, Hickel and others[21,22] published details of the changes and improvements made to the criteria since 2007. The "clinically poor (replacement necessary)" criteria were detailed as follows:

Esthetic Properties

- Surface luster: Very rough, unacceptable plaque-retentive surface.
- Staining: (a): Surface. (b): Margin. (a): Severe surface staining and/or subsurface staining, generalized or localized, not accessible for intervention. (b): Deep marginal staining, not accessible for intervention.
- Color match and translucency: Unacceptable.
- Esthetic anatomical form: Form is unsatisfactory and/or lost. Repair is not feasible/reasonable.

Functional Properties

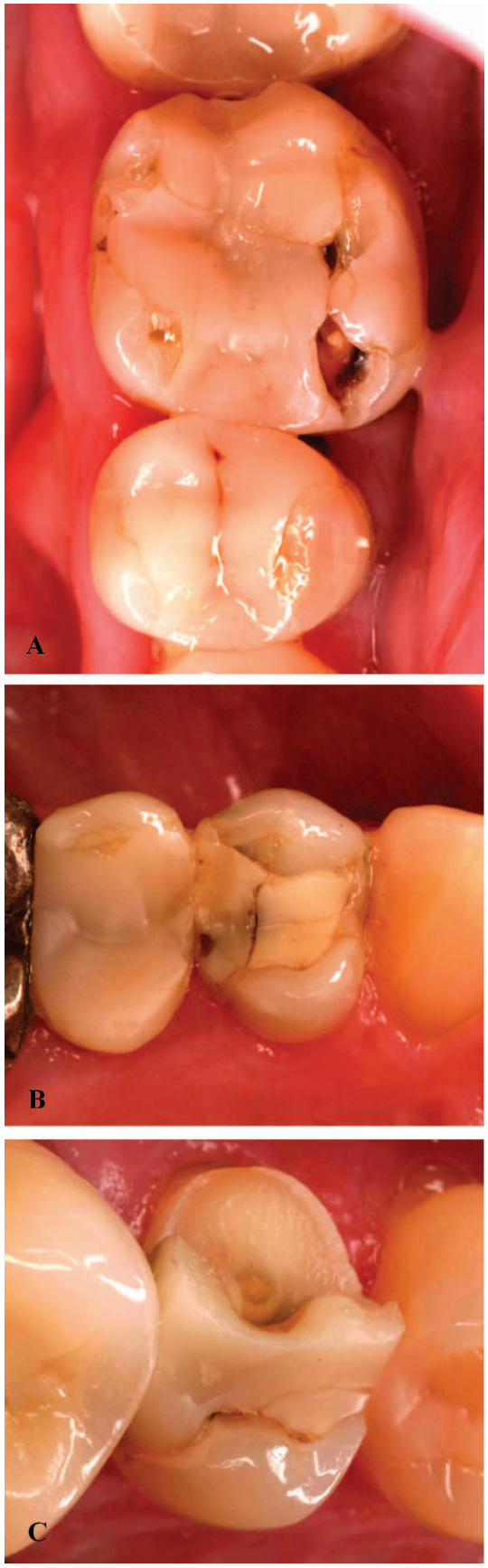
- Fracture of material and retention: (Partial or complete) loss of restoration or multiple fractures.
- Marginal adaptation: Restoration (complete or partial) is loose but *in situ*/generalized major gaps or irregularities.
- Occlusal contour and wear: (a): Qualitatively. (b): Quantitatively. (a): Wear is excessive. (b): Restoration or antagonist >50% of corresponding enamel.
- Approximal anatomical form: (a): Contact point. (b): Contour: (a): Too weak and/or clear damage due to food impaction and/or pain/gingivitis. (b): Insufficient contour.
- Radiographic examination (when applicable): Secondary caries, large gaps, large overhangs/apical pathology/fracture/loss of restoration or tooth.
- Patient's view: Completely dissatisfied and/or adverse effects, including pain.

Biological properties.

- Postoperative (hyper-)sensitivity and tooth vitality: Intense, acute pain or nonvital tooth.Endodontic treatment is necessary, and restoration has to be replaced
- Recurrence of caries (CAR), erosion, abfraction: Deep caries or exposed dentin that is not accessible for repair of restoration.
- Tooth integrity (enamel cracks, tooth fractures): Cusp or tooth fracture.
- Periodontal response (always compared to a reference tooth): Severe/acute gingivitis or periodontitis with or without overhangs, gaps, or inadequate anatomic form.
- Adjacent mucosa: Suspected severe allergic, lichenoid, or toxic reaction
- Oral and general health: Acute/severe local and/or general symptoms.

TRANSLATION INTO CLINICAL PRACTICE

While important in the clinical testing of materials, the USPHS Charlie ratings and the FDI World Dental Federation's "clinically poor (replacement necessary)" criteria have never been promoted let alone adopted as criteria for the replacement of restorations in the everyday clinical practice of dentistry. This has left practitioners making traditional, empirical decisions about the clinical acceptability of restorations in clinical service, with all the variability that this brings. It is suggested that most practitioners practice what they were taught in dental school, typically tempered by experience in clinical practice and acquired skills, developed largely through self-learning, in assessments of risk of failure (need for urgent treatment) before the next time they anticipate the patient returning for routine dental care. For example, if a patient returns every 6 months for a "checkup," then the practitioner questioning the clinical acceptability of a restoration is believed to be more inclined to "wait and see" than to intervene, in particular if he or she placed the restoration and was satisfied with the clinical outcome of preparation and restoration placement and the patient is not expressing any concerns about the comfort, function, viability, or appearance of the restoration. In contrast, the practitioner may decide to intervene and replace the questionable restoration if, for example, the patient is about to set off to some remote location for a prolonged period and will not have access to any dental care or is a poor, irregular dental attendee who last sought routine dental care several years previously and has a history of early restoration failure. A further consideration is traditional, now misguided thinking by patients that a "brand new" replacement restoration rather than a repair would be in their best interests as and when



the dentist needs to do something to a previously filled tooth. This raises the issue of the need for patient education in matters pertaining to the refurbishment and repair of existing restorations. Perhaps, in particular, the term "repair" may convey the wrong message to the patient.

For the practitioner, there are key issues to consider when assessing the sufficiency of existing restorations and making treatment decisions:

1) Is the patient requesting or expecting a replacement restoration? A patient who is dissatisfied with the appearance of a restoration or is experiencing pain, sensitivity, or discomfort associated with, for example, food impaction or sharp edges caused by a fracture of the restoration or remaining tooth tissue may reasonably be expecting operative intervention to resolve the difficulty.
2) Are there lesions or forms of restorations failure present that carry an unacceptable risk to the viability and retention of the tooth if not addressed by some means of intervention? Examples of such lesions and forms of restoration failure are illustrated in Figures 2 and 3.
3) Would intervention, in particular intervention that is unexpected by the patient, cause more harm than benefit, or have any lesions or signs of restoration failure remained unchanged for some time, are they unlikely to progress, and could they reasonably be monitored, subject to the approval of the patient? A clinical case extending over 15 years, illustrating the possibility to monitor rather than intervene, contrary to the wishes of the patient and in the absence of any clinically significant deterioration in the condition of the restorations, is shown in Figure 4. Such cases highlight the possible conflict between patient-centered care and clinical excellence.

REFURBISH OR REPAIR

The situation described above has been confounded in recent years by the development and validation of techniques for the refurbishment and repair of restorations as an alternative to restoration replacement, in particular in patients who are regular

Figure 2. *Some clinical examples of restorations that should be replaced as a consequence of bulk fracture with the probability of further, clinically significant deterioration (A); progressive, pulp-threatening secondary caries and fracture (B); and combined restoration and cusp fracture with loosening of the remaining portion of the restoration (C).*

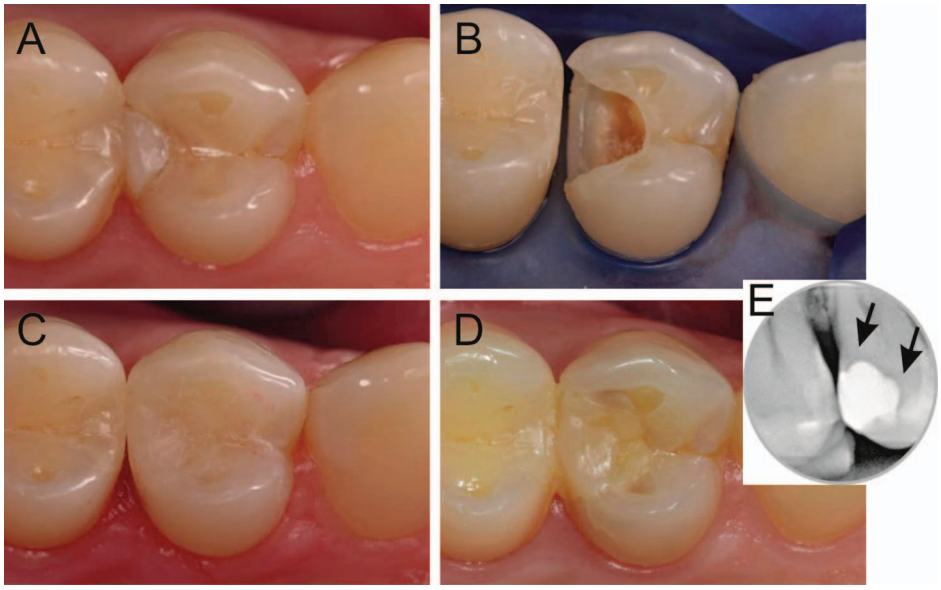


Figure 3. *Treatment decisions for restoration replacement should rely mainly on marginal integrity as assessed clinically rather than radiographically. A decision was made to replace the restoration illustrated (A) following adhesive failure. After complete (enamel and peripheral dentin) and partial (visible as brown area toward the pulp) caries removal (B), a replacement composite restoration was placed (C). Follow-up, five years later (D), revealed intact margins clinically but some wear. The insert of the restored surface in a bitewing radiograph shows proximal-cervical marginal integrity but a radiolucency between the restoration and dentin—the so-called Mach-Band effect. This area should not be (mis)interpreted as caries in need of treatment but rather as a radiographic phenomenon between adjacent areas with different grayscale values. A similar appearance may be observed following ultraconservative caries removal.*

attenders and maintain a good standard of oral health, refurbishment (Figure 5) being considered the correction of the shortcomings of a restoration without damage to the adjacent tooth tissues or the addition of new restorative material and repair (Figure 6) being defined as the correction of a localized defect in a restoration involving the addition of restorative material.[5,23] Developments in this area are such that the option of replacing a defective or failing restoration may, in the foreseeable future, be considered to be indicated only when the possibility of repair has been ruled out. Indications for the repair of restorations have been reported to include[5,23] the following:

- Correction of limited marginal openings and cavomarginal ditching
- Management of localized marginal staining
- Treatment of early lesions of secondary caries
- Repair of fractures that do not threaten the viability of the remaining restoration and tooth tissues
- Chipping of restoration margins
- Management of wear
- Correction of unacceptable esthetics
- Restoration of an endodontic access cavity prepared through an existing restoration

When considering the replacement of a restoration, the wishes of the patient, the risk of causing more harm than benefit, and the possibility of monitoring unsatisfactory but stable situations should be taken into account when considering whether to refurbish or undertake a repair. Again, such decision making may pose conflicts between the provision of clinical excellence and patient-centered care. A recent 10-year follow-up study reporting similar clinical outcomes for repair and replacement, notwithstanding the replacement procedures having inevitably resulted in increases in the size of restorations, included interventions on "bravo" rated restorations, which, in hindsight, can be questioned as unnecessary where monitoring may have been the best form of patient care.[24]

OTHER CONFOUNDING VARIABLES

Other variables that may, in effect, act as criteria in decision-making processes applied to defective and failing restorations include remunerative systems that do not yet include explicit provision for refurbishment or repair as an alternative to restoration replacement and deep-seated, traditional beliefs among certain practitioners and patients that the best approach when faced with a defective or failing restoration is "if in doubt, take it out" (and replace it). The growing body of evidence demonstrating the efficacy of refurbishment and repair,[8-10] where indicated clinically, will hopefully counter such confounding variables sooner rather than later.

THE WAY FORWARD

In the interest of promoting preventively oriented, patient-centered, minimum intervention operative dentistry, it must be recognized that any attempt to define universally applicable, user-friendly, let alone

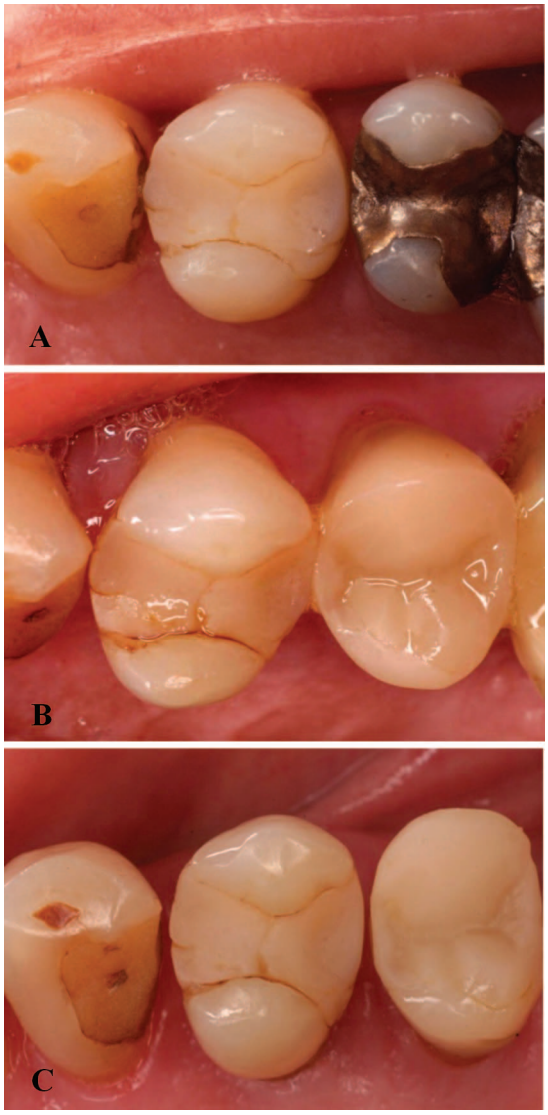


Figure 4. *Illustrations of the upper left quadrant of a female patient, reluctant to have replacement restorations. (A): Distal restoration in canine (more than eight years in clinical service), mesio-occlusal-distal (MOD) composite restoration in the first premolar (three years in service), and an eight-year-old amalgam restoration in the second premolar. The restoration in the first premolar has a Charlie rating for marginal adaptation. (B): Ten years later, the restorations in the canine and first premolar are still in service. There is visible progression of deterioration of the restoration in the first premolar in terms of marginal adaptation, marginal staining, and the extent of the fracture damage mesially; two years previously, the amalgam restoration in the second premolar was replaced, following fracture of the buccal cusp and 16 years in clinical service. (C): A further five years later (i.e., 15 years after Figure 4A was recorded), the restorations in the canine and first premolar are still in service, having served for >23 years and 18 years, respectively. The teeth are migrating as a consequence of progressive periodontal deterioration; however, the restorations were expected to remain in clinical service until extraction was considered to be indicated as a consequence of advanced, progressive periodontitis.*

workable criteria for the replacement of restorations in "frontline" everyday clinical practice will involve compromise, which may disadvantage as many patients as it benefits. The FDI World Dental Federation's "clinically poor (replacement necessary)" criteria provide a list of situations in which restoration replacement should be considered necessary, and, as such, this list provides a useful guide as to when to normally resort to restoration replacement despite the negative effects of such intervention, including enlarged preparation, further weakening of already weakened remaining tooth tissues, and new insult to the dental pulp, all fueling the so-called drill-and-fill restorative death spiral. Building on the refurbish or repair evidence base and the FDI World Dental Federation's "clinically poor (replacement necessary)" criteria, new, forward-looking guidance for restoration replacement in clinical practice may be formulated around the following criteria:

- The restoration has unacceptable qualities, with the probability of further, clinically significant deterioration and/or lesion progression.
- Repair is contraindicated.
- The benefits of replacement outweigh the negative effects and possible harm.
- The prospects for an acceptable clinical outcome are favorable.
- The patient consents.

The range of knowledge, skills, understanding, and experience required to be effective in such patient-centered decision making in operative dentistry must not be underestimated. Indeed, it could be considered to be as much an informed art as a science. It is considered difficult to practice, let alone teach.

Within this guidance, it is should be emphasized that monitoring, refurbishment, or repair should become the "treatment of choice" as the least invasive approach for the management of a deteriorating restoration. When this is not appropriate, replacement should be considered. In applying such guidance, the practitioner, in the ethos of evidence-based practice, should be familiar with best evidence, exercise his or her clinical expertise to the best possible effect, and take account of the views and wishes of the patient, who may need to be educated in the merits of refurbishment and repair over the replacement of defective restorations. Decision making in operative dentistry, past, present and future, cannot be considered an "exact science," in particular, decision making with regard

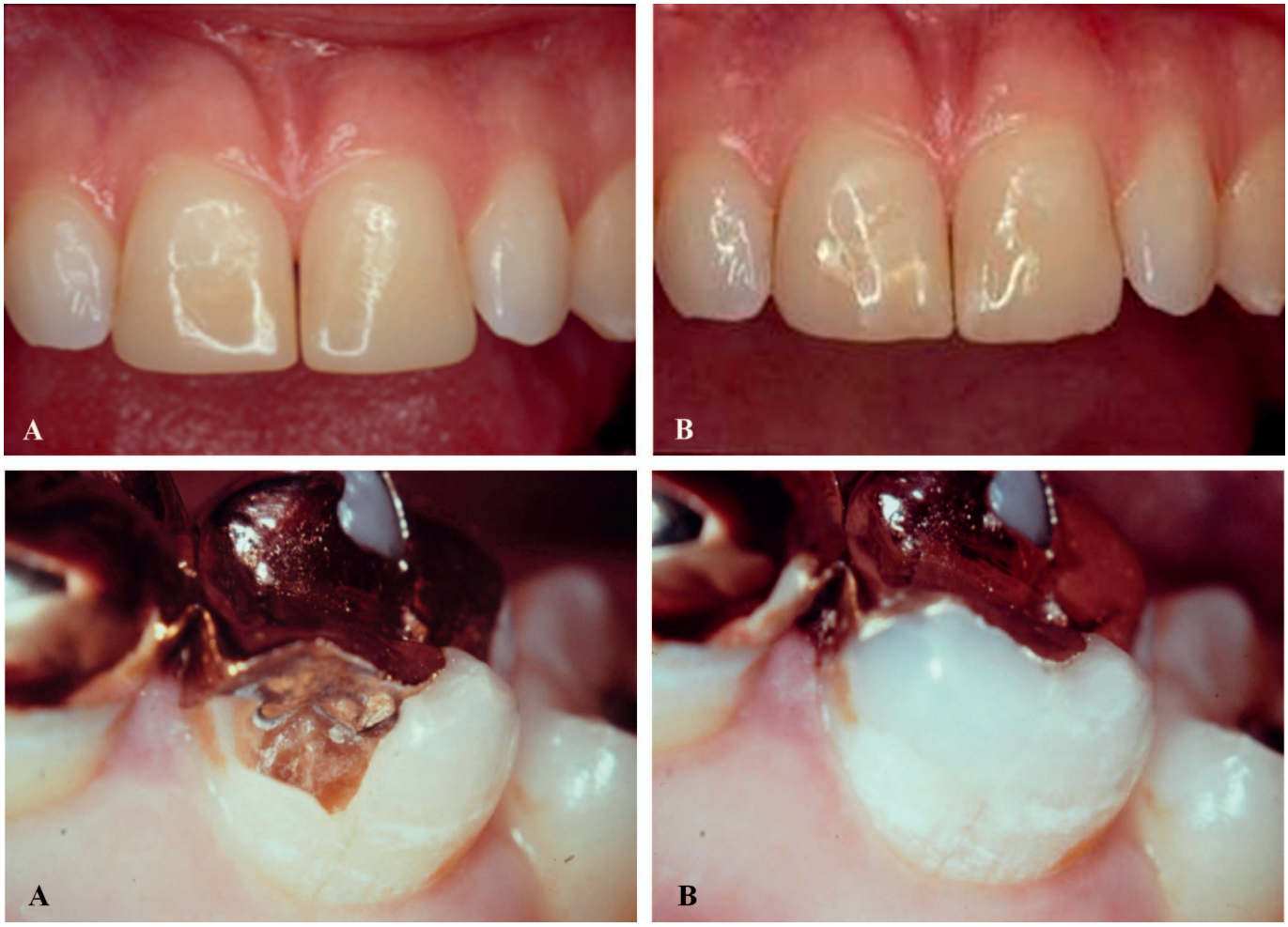


Figure 5. *An example of restoration refurbishment. The patient presented five years after the restoration of his fractured incisors with direct composites, expressing growing concern over the appearance of the restorations (A) and requesting that the restorations be replaced. Following refurbishment (B), the patient decided to retain the restorations and defer any further operative intervention.*

Figure 6. *An example of the repair of a restoration. This older patient presented complaining of sharp edges following the loss of a cusp (A). The cast gold inlay, which had been in clinical service for many years, was firmly retained, and the exposed dentine surface was hard. The decision was taken to carry out a direct composite repair and to subsequently review the need to refurbish (reburnish) the inlay margins away from the repair. The repair was quickly completed without the need for local anesthesia, and the patient was delighted with the outcome.*

to the replacement of restorations, one of the most common procedures in general dental practice.[1] While some practitioners and others, including consumers and funders of oral health care services, may wish decision making in operative dentistry to be driven and possibly dictated by unequivocal "treat" or "no treatment" criteria, this, it is suggested, would not be in the best interests of patients given existing knowledge and understanding of the value and potential of refurbishment and repair techniques. If nothing else, the options, when considering what action to take with respect to an existing restoration with less-than-ideal clinical features should be to monitor, refurbish, repair, or possibly replace, with the reasons for making whatever decision is reached being clearly recorded in the patient's clinical records, ideally together with clinical photographs. The knowledge that this approach is now being widely taught and promoted across the world is viewed as a major step toward the universal adoption of minimum intervention dentistry.[24-28] A major turning point in many countries would be the provision of refurbishment and repair procedures in insurance and third party–funded care programs.

It is acknowledged that further research in the area would be of immense value, for example, research to develop a readily applicable and reproducible scheme to facilitate the risk assessment of defective and failing restorations and investigations

to enhance the evidence base on repair *vs* replacement. Research to develop new diagnostic tools and processes to ascertain the functionality and sufficiency of existing restorations would be of great value also. Such research should run in parallel with research in related areas, such as research on regenerative endodontic procedures.[29]

In the meantime, practitioners who examine existing restorations with the view "if in doubt, take it out" are to be encouraged to adopt the modern mantra of "as a last resort, take it out" and to concurrently apply, as a matter of routine, state-of-the-art criteria, materials, and techniques for the refurbishment and repair of defective restorations.

Conflict of Interest

The authors of this article certify that they 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.

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