Operative dentistry: the missing clinical standards

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Abstract
Since the development of advanced adhesive technology, the use of amalgam has declined significantly. The search for amalgam substitutes, i.e., restorative materials which maintain similar clinical function and cost-effectiveness as amalgam, has so far been unsuccessful. It has also become evident that a considerable confusion prevails regarding the objectives of restorative procedures. In absence of national and international standards, the products—the restorations—are assessed according to varied criteria. In placing restorations, three objectives are attained, at most: a) tooth preservation, b) tooth preservation and function, and c) tooth preservation, function, and imperceptible restitution. The learning objective of this article is to discuss the positive effects that could be attained by defining the standards, terminology, and the quality assessment criteria for operative dentistry in regard to the patients and the dental profession.

Reference

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Operative Dentistry:
The Missing Clinical Standards

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ABSTRACT
Since the development of advanced adhesive technology, the use of amalgam has declined significantly. The search for amalgam substitutes, i.e., restorative materials which maintain similar clinical function and cost-effectiveness as amalgam, has so far been unsuccessful. It has also become evident that a considerable confusion prevails regarding the objectives of restorative procedures. In absence of national and international standards, the products — the restorations — are assessed according to varied criteria. In placing restorations, three objectives are attained, at most: a) tooth preservation, b) tooth preservation and function, and c) tooth preservation, function, and imperceptible restitution. The learning objective of this article is to discuss the positive effects that could be attained by defining the standards, terminology, and the quality assessment criteria for operative dentistry in regard to the patients and the dental profession.

Dental care and operative dentistry require defined objectives, and the maintenance and restoration of oral health is defined as follows: Primary oral health is the absence of disease of the teeth, the periodontium, and of the oral mucosa, as well as the ability to function of the dentition. Secondary oral health is achieved by rectifying any damage that has occurred, thereby maintaining or restoring functional ability. An international consensus could probably be achieved regarding the rectification of damage; however, the question of what the attainment of functional ability should include

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Figure 1. The different service life of amalgam restorations as assessed in several in vivo studies, demonstrating the importance of the operator factor.

provokes a wide range of answers. Furthermore, the given definition of oral health fails to place adequate emphasis on the significance of aesthetics.

In the autumn of 1996, a congress of the Academy of Dental Materials was held in Munich. At the conference, a Congress Report was produced, with the title "Clinically Appropriate Alternatives to Amalgam" and the subtitle "Biophysical Factors in Restorative Decision-Making," with 12 presentations and 53 abstracts.

This work comprises more than 280 pages. However, there is no clear definition of the concept of amalgam alternatives, what they are, and what objectives they serve. It is impossible to establish what are the "clinically inappropriate alternatives" and "biophysical factors." The hoped-for directive
concerning “restorative decision-making” remains outstanding, and no clearly formulated general directives were achieved.

Such lack of clarity in the course of a congress of undoubtedly high professional competence is possible only because of the chaos in operative dentistry, extended by the confusion in terminology. The current problems in operative dentistry are relatively clear, and it may be assumed that the profession will have to manage without amalgam in the future, whether partly or completely. Materials and operative procedures must be developed to replace amalgam with similar quality and cost (amalgam substitutes). Restorations and techniques will have to be defined that will equal or surpass amalgam in terms of biocompatibility and aesthetics during consistent use of adhesive techniques with regard to preservation and protection of enamel and dentin (amalgam alternatives)."  

THE CURRENT STATE OF OPERATIVE DENTISTRY

Operative dentistry lacks mandatory, clearly defined terminology and standards. Currently, its products, i.e., restorations, are assessed according to multiple and inconsistent criteria.

Terminology

In the media, the term “dentist” is associated with the simple, fast, and most profitable use of restorative materials, oriented towards mechanic amalgam techniques, with a minimum of technique sensitivity. Often, terms like “routine servicing” are used; however, this terminology is defamatory for the reputation of the profession, and the objective of “serving the public” is neglected.

The term “materials” considers properties, such as adhesiveness, physical characteristics, biocompatibility, and others. There is a confusion of objectives; clinically speaking, compliance with particular material properties cannot be regarded as the primary goal. Defined material properties are, at most, a precondition for fulfillment of the real objective — the ability to place restorations that fulfill clear standards, which are yet to be defined.

The term “patient” is associated with factors such as painless treatment, time spent, aesthetics, costs, environmental compatibility, and biocompatibility. However, since the patients are unaware of the relevant assessment criteria, they can objectively assess neither the product (restoration) nor the short- and long-term costs of treatment.

In the criterion of “total expenditure for dentistry,” allotted treatment time, actual costs, and international tariff systems (fee regulations) are of interest. Such matters can have a lasting influence on dentistry as practiced within the framework of the National Health Service, particularly if only treatment, but not prevention, diagnostics, and dental care are reimbursed.

The term “clinical studies or experience” has the inherent defect that it is not even a criterion. Comparison of the durability of amalgam fillings (Figure 1) with the clinical performance of a componer in Class V studies confirms that clinical studies cannot objectively record the potential

Figure 2. Nonfunctional temporary restoration (chemically cured glass-ionomer cement) following 6 months in vivo, fulfilling the requirements of Standard 1.

Figure 3. Functional temporary restorations (light-cured resin-reinforced glass-ionomer cement) following 6 months in vivo, fulfilling the requirements of Standard 2.

Figure 4. Amalgam restorations following a service of 10 years, perfectly fulfilling the requirements of Standard 2.
of a restorative material. The skill of the operator and the technique applied have just as important a role. The technique is often described inadequately, and the reasons for replacement of a restoration are not objectively substantiated. "Too often, the assessment criteria are not adequate; eg, in the authors' experience, a survival rate of 95% over 3 years may be acceptable for average expectations, but for advanced dental treatment it is a failure.

The terms "market dentistry" and "consumer dentist" have highly unfavorable consequences. New products are associated with innovation and progress, even when this is not applicable. This compels the dental industry to continue the innovation of new products. Tried-and-tested products sell only at medium level; as in the fashion industry, they have to be launched again and again, often without attaining linear progress. Therefore, the characteristics of the product have to be directed towards the user and not towards the requirements of the patient.

The tacit permission of "confusion" may be academic self-protection. Without problems, which exist to be solved, there will be no grants, no need to publish, and no opportunity for young researchers to make their mark.112

Finally, "professional self-preservation" should be mentioned. The classic expression of this is the death spiral of the tooth, which conceals the fact that, in this kind of dentistry, the patient exists for the dentist and not the dentist for the patient. Awareness that primary and secondary prevention merely change the work of the dentist, without making him superfluous, is still not acknowledged universally.13

Characterization of the terminology demonstrates that operative dentistry is not concerned merely with seeking new materials to replace at least amalgam. If genuine progress is to be achieved, clear standards must be defined and applied as mandatory, first nationally for a particular country, then internationally.

The Standards

With the restorations created under secondary oral health in operative dentistry, various goals are pursued (Table 1), whereby each higher standard is based on the fulfillment of the requirements of the lower standard or the lower standards.

Standard 1 — Preservation of the remaining tooth structure

Once the elimination or inactivation of caries is achieved, it is a matter of preserving the remaining hard tissue and protecting the pulp. This essential minimal objective is within the sights of the Atraumatic Restorative Technique.4 The same applies to the simplest forms of provisional fillings (Figure 2), which, in addition to an adequate service life, have to protect the tooth from caries and stimulate the pulp.

Standard 2 — Function

The remaining hard tissue has to be preserved and the function of the tooth restored. This concept is characteristic of "up-market" provisional restorations (Figure 3),
amalgam (Figure 4), and gold restorations (Figure 5). Restorations utilizing amalgam substitutes should also conform to this standard.

**Standard 3** — Imperceptible restitution / aesthetics
Preservation of the hard tissue and the restoration of function are prerequisites. In addition, the restoration must be imperceptible at conversation distance and remain such throughout the stipulated service life. Qualitatively, the restorations of important anterior dentition (Figures 6 and 7) and restorations performed with amalgam alternatives (Figures 8 and 9) have to meet these requisites.

At present, there are various classes of dentistry: Standard 1 is the dentistry for developing countries, emergencies, or for financially limited patients. Standard 2 is world-wide standard dentistry, in conformity with the amalgam age. It is dentistry of traditional dental training, of patients with a modest dental intelligence quotient, and of National Health Service dentistry, as applicable to the general public. Standard 3 is discretionary dentistry, at least currently, ie., outside collective insurance, dentistry for the dentally aware and financially secure.

Establishing these standards in operative dentistry and defining the restorative goals of the various standards of dentistry, however, is not enough. The three standards described need to be defined not only qualitatively but also quantitatively, by means of evaluation criteria. A difference could then be made between static initial quality and dynamic performance.

Static initial quality is influenced by the dental practice (equipment, facilities, ancillary staff), the dentist (training, ability, skills, knowledge), the patient (cooperativeness during treatment), the operative technique, and the material (simplicity, technique sensitivity). For dynamic performance, the achievement of the demanded static initial quality is a relevant prerequisite. In addition, the materials (physical properties, durability), the patient (dental IQ, self-care, drinking and eating habits, saliva composition and flow rate, etc.), and maintenance of the restoration (follow-up, nondestructive professional tooth cleaning, refinishing) have an important role.

These qualities require quantitative definition, based on USPHS (United States Public Health Service), SAMS (Self-Assessment Manual and Standards), and AAPD (American Academy of Pediatric Dentistry) criteria, by means of the parameters set forth in Table 2. Dynamic performance criteria has to be established as to 1) how soon postoperative deterioration in quality is acceptable and 2) where should be the limits of deficiencies in quality, requiring replacement of a restoration.

**QUANTITATIVE ASSESSMENT OF DIFFERENT RESTORATIONS**
For each type of restoration, a standard should be established by which to achieve the initial static quality and the required durability. Minimum limits should be set for dynamic performance, below which quality should not

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### Table 1: Restorations — Standards (Secondary Oral Health)

<table>
<thead>
<tr>
<th>Target</th>
<th>Restoration Type</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preservation of enamel and dentin / dental pulp</td>
<td>• Atraumatic restorative technique (ART)</td>
<td>Preservation (Standard 1)</td>
</tr>
<tr>
<td>Preservation and restoration of tooth contour, interproximal contact and occlusion</td>
<td>• Functional temporary restorations</td>
<td>Function (Standard 2)</td>
</tr>
<tr>
<td>Preservation of function and imperceptible restitution / aesthetics</td>
<td>• Aesthetic restorations placed with amalgam alternatives</td>
<td>Imperceptible Restoration (Standard 3)</td>
</tr>
</tbody>
</table>

*Currently experimentally.

1According to the current clinical potential of glass-ionomer cements, resin reinforced glass-ionomer cements and composites.

2Currently not available for non-bearing restorations in permanent teeth.

3Direct composite fillings comprising preventive resin restorations, adhesive restorations, Class I and II fillings; restorations comprising inlays, onlays, and partial-coverage crowns, fabricated of either resin composites or ceramics.

4Uses composite restorations composite or ceramic veneers and partial crowns.

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**Figure 8.** Composite restorations following 8 years in vivo, effectively fulfilling the requirements of Standard 3.
be allowed to fall within the stipulated service life. A list of all descriptions is outside the scope of this presentation; however, a number of important restorations are discussed from the point of view of standards and quality assessment.

**Stress-Bearing Restorations in Posterior Deciduous Teeth**

Standard 2 must be achieved for these restorations. Regarding static initial quality, alpha-values must be achieved for form, function, marginal integrity, and sensitivity. Caries-inhibiting potential and caries-protective properties should be set particularly high. Regarding dynamic performance, wear, and opposing tooth wear should be similar to that of natural dentition (Figure 10). Biocompatibility and sensitivity should not fall below alpha-values. Open margins could be permissible, provided they do not increase the risk of secondary caries that will reduce the service life of the restoration. Fillings would have to last until natural exfoliation of the tooth. These defined objectives are achievable with high-quality composites. Second generation composites, which release more fluoride, may come even closer to fulfilling these requirements.

**Amalgam Substitutes**

Amalgam substitutes should fulfill only Standard 2. Restorative equality could be set relatively low, but marginal integrity would have to be of alpha-level in the case of static initial quality. Caries-inhibiting potential and caries-protective properties should be important, since it must be borne in mind that marginal openings occur inevitably in stress-bearing composite restorations placed in permanent teeth. Radiopacity of 1 mm thick material samples must be greater than that of enamel, i.e., $\geq 2.5$ mm of thickness of equivalent aluminum. In dynamic performance quality, high demands must be made regarding biocompatibility and the elimination of tooth sensitivity.

Wear and antagonistic wear should be at least on a par with amalgam (Figure 11). Open margins with marginal discoloration could be tolerated, provided service life is not reduced and the risk of secondary caries increased (Figures 12 and 13). The average longevity should be the same as for amalgam fillings, depending on the country, i.e., from 2 to 10 years. Taking into account the general standard of dentist training, amalgam substitutes should be simple and inexpensive and fulfill their required life expectation without maintenance.

To date, these targets have not been achieved, and are even less likely to be achieved if Standard 3 is required for amalgam substitutes. Composites are not sufficiently wear-resistant. The risk of secondary caries in the open margins following a short period in use remains high, i.e., not even the requirements of Standard 1 are fulfilled. Therefore, the suitability of composites as a provisional filling material is in doubt, unless they demonstrate more efficient caries-protective characteristics. Primitively placed composite resin restorations might present a brief initial impression of suitability for Standard 3. When composite resins are used in this manner, the restoration margins
are usually open, and the marginal discoloration is “programmed” in. In the course of dynamic performance quality, Standard 3 will assuredly not be attained. Due to the lack of caries-protective properties, the risk of secondary caries is relatively high, ie, deficiencies in achieving Standard 1 are unavoidable (Figures 14 and 15). Therefore, composite resin restorations, placed according to simplified operative techniques, are expensive and inadequate, since they fulfill neither the objectives nor targets of Standards 1 and 3.

**Amalgam Alternatives**

In the case of amalgam alternatives, only 100% fulfillment of Standard 3 is acceptable. To attain the goal of “imperceptible restitution,” alpha-values are essential for restorative match, texture, and marginal integrity (≥ 90% continuous margin); Standards 1 and 2 should also be of alpha-rating. Regarding dynamic performance quality, high marginal integrity must remain stable under load to exclude restorations which reveal marginal discolorations and to predictably exclude secondary caries. Surface texture, stain accumulation, wear, and antagonistic wear must remain similar to enamel; restoration discolorations are not permissible (Figures 16 through 18).

Service life should be set at 10 years, whereupon the necessity for replacement would be acceptable. This objective is most probably attainable today. The relevant operative concepts are available and tested, as are the necessary material chains. Restorative materials are products which are partly of a luxury nature. Dental patients are not merely patients but also clients. Therefore, a right to selection is uncontested, particularly if the patient/client is primarily or exclusively responsible for the payment. An explanation of the standards and quality assessment criteria for the layman is, therefore, unavoidable.

**FUTURE ROLE OF PATIENTS**

Restorative materials are products, which are partly discretionary in nature. Dental patients are not merely patients but also consumers. A right to selection is, therefore, uncontested, particularly if the patient/client is primarily or exclusively responsible for payment. An explication of the standards and quality assessment criteria for the layman is, therefore, unavoidable. The proven four-fold evaluation of alpha, beta, gamma, and delta could be converted to a two-part positive-green / negative-red evaluation system. Such a system would allow the patient to recognize newly placed restorations which are unmistakably of poor quality or defective with regard to the prescribed standards. Moreover, the patient would have the opportunity to recognize or acknowledge the need for a replacement of the restoration prior to the occurrence of further damage.

**DISCUSSION**

Viewed realistically, the chances are limited that Standards 1 to 3 for “preservative,” “functional,” “imperceptible,” and “esthetic” restorations will be internationally defined and quantitatively characterized in operative dentistry.

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**Table 2**

**Quantitative Quality Assessment Criteria — Static Initial and Dynamic Perforatory Quality (Following the USPHS, SAMS, and AAPD-criteria)**

| Standard 1 | — Caries inhibiting potential (sealing or adhesive capacity, therapeutic effects). |
| — Caries protective properties (fluoride release, release of chemopreventive agents). |
| — Surrounding tissue protecting properties. |
| — Pulp protecting properties. |
| — Bio-compatibility. |
| — Service life. |

**Standard 2**

(In addition to Standard 1 requirements)

— Form (tooth contour, compatibility with oral hygiene, gingival health). |
| — Function (proximal contacts, occlusal contacts, absence of interferences in excursive movements, wear and antagonistic wear). |
| — Postoperative sensitivity / sensitivity. |
| — Marginal integrity. |
| — Restorative match. |
| — Restoration fractures. |
| — Tooth fractures. |
| — Secondary caries. |
| — X-ray opacity. |
| — Plaque affinity. |

**Standard 3**

(In addition to Standard 1 and 2 requirements)

— Surface texture. |
| — Discoloration / Staining. |
| — Interface staining / discoloration / ditching (restoration / tooth interface; restoration / luting restorative, luting restorative / tooth interfaces). |

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**Figure 12.** Following 6 months in vivo, marginal discoloration due to marginal openings is evident but still in accordance with requirements of an amalgam substitute (Standard 2).
It is well known that there has been no success even in defining the initial quality to be required for amalgam fillings on the international level, not to mention dynamic performance quality. At the national level, the picture is different. In Switzerland, for example, by 1999 the dental profession will be obliged to present such definitions and descriptions not only for operative dentistry but for all areas of dentistry. This is a quid pro quo for the currently valid generous time-based fee regulations for dentistry, which in Switzerland is 93% privately financed. In a country that defines the standards and quality descriptions discussed and makes them mandatory, the consequences for dentistry would be as follows:

- Secondary oral health will become quantifiable, allowing an accurate definition and cost-assessment of the health policy goals.

- The practicing dentist will have to attain these standards and quality requirements, i.e., the clinician must master and routinely use those operative techniques and materials which reach their targets in accordance with the standards. Therefore, a time-based fee regulation would be justified.

- The fact that the patient/layman can also assess the quality of dental services to a certain extent will provide a stimulus towards quality and contribute to quality assurance. The patients will feel less ignored, thereby improving the patient/dentist relationship, faith in dentistry, and the image of the dentist.

- Health insurance systems will also have to respect quality. Underpayment for dental work has always resulted in an increase in productivity of low quality restorations. A fee of 50 DM ($30 US) for an MOD amalgam filling at a German National Health practice, corresponding to an allotted treatment time of 7.5 minutes for placing such a filling, will no longer be possible. 18

- Research could focus on standards. For example, if Standard 2 was generally accepted for amalgam substitutes with the corresponding characteristic qualities, a substitute for amalgam would be immediately forthcoming. At the launch of every new product, evidence would be required to exhibit compliance with standards for the indications targeted. Science would then clearly come before marketing.

- Basic training, postgraduate education, and continuing education would also have to be subject to the standards. Proof of performance would have to be provided for all clinical concepts introduced. Simplified operative techniques, as published in the dental tabloids for placing composite resins, such as use of wooden wedges, steel matrices, absence of rubber dam, single-component adhesives, flowable composite resins, bulk placement technique, etc., would no longer be tenable. Due to open margins and the lack of caries-protective qualities found in resin composites, restorations performed according to these descriptions are incapable of fulfilling...
either the commandment for the preservation of enamel and dentin or aesthetic requirements, even in the interim period. State-of-the-art would then no longer be judged by what is fashionable, but how and what materials the standards can be achieved.

**CONCLUSION**

Two-and-a-half years remain until the beginning of the next century. This period should be used in operative dentistry. The confusion and programmed failure could be eliminated at a stroke by the formulation of restoration standards with the corresponding criteria for quantitative assessment of static initial quality and dynamic performance quality. Restorative dentistry would then become true to its calling, and a further improvement in oral health could be expected without additional cost.

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