

Factors influencing the choice of dental material and procedure for crown restoration of posterior teeth – design of a “decision guide”

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Abstract. The aim of this study was to analyze the factors influencing a clinical choice of different methods of posterior teeth reconstruction. Firstly, the factors influencing the clinical therapeutic choice were determined, and then the material functional properties were analyzed according to available literature, including the analysis of the restoration's longevity and the main causes of its failure. The available types of dental restorations were analyzed and compared between each other; those which solidify directly in the mouth (amalgams, resin-based composites for direct restoration) and those made in a dental laboratory and then placed in a previously designed tooth cavity (resin-based composites for the indirect restorations, dental ceramic inlays and crowns) in order to make a conclusion about their advantages and limits which influence a therapeutic choice.

Key Words: dentistry, crown restoration of posterior teeth, therapeutic choice, decision making.

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Introduction

In contemporary dental practice, there are various different currently available therapeutic possibilities for a restoration of tooth, damaged by tooth diseases or trauma of any kind (Alb 2008). This study concerns the problems of posterior teeth restoration, due to their challenging reconstruction in aspects of a tooth-decay extension, high occlusal forces presence, and various possible therapeutic choices (Alb 2008).

During the last two decades, a revolutionary change of tooth preparation principles, indications and types of restorative materials appeared in a dental practice (Salerno & Diaspro 2015). Currently, modern means of investigation and assessment of the three-dimensional structure and morphology of the biomaterials and restorative dental structures are used in dental practice (Alb et al 2010; Berezina et al 2015; Lainović et al 2013, 2015, 2016; Moldovan et al 2015; Țălu 2012a,b; Țălu et al 2015a,b,c,d; Țălu 2015e; Țălu et al 2016a,b,c).

The most commonly used restorative materials for posterior restorations, amalgam fillings and gold inlays, used in '80s, became suppressed to only 20%, or less, of all contemporary posterior restorations (Burke et al 2001; Christensen 2005; Dietschi et al 2001; Mörmann 2006). Those materials have been replaced by the more aesthetic ones: resin-based composites (RBCs), for

both direct and indirect restoratives, and dental ceramics which were significantly technologically improved in order to expand its therapeutic possibilities.

The restorations produced in a dental laboratory can be made of various ceramic types: zirconia, lithium-disilicate reinforced glass ceramics, glass infiltrated alumina, or glass infiltrated alumina-zirconia. Those ceramics can be either directly sintered in the laboratory in accordance with a required principles, or can be milled using a CNC machine incorporated in contemporary computer aided design/computer aided manufacturing – CAD/CAM systems for dental applications. Those machines can prepare a final piece of dental inlay, crown or fixed partial denture, milling the pre-sintered or fully-sintered ceramics, and can be used even without a need for the dental laboratory engagement (in-office CAD/CAM system – CEREC, Sirona) (Mörmann 2006).

All of those restorative systems have different properties, and their advantages and disadvantages influence the restoration quality consequently defining their costs.

The objective of a dental crown restoration is to reconstruct morphological and functional properties of a damaged tooth. Achieving of these goals is influenced by properties of available

Table 1. Criteria for the evaluation of materials for posterior teeth reconstruction (Alb, 2008; Christensen 1998)

Evaluation criteria	Amalgam	Posterior composite	Glass-ionomer	Gold inlay (cast)	Composite inlay
Longevity	8-12 years	6-8 years in occlusal stress-free zones	No data ~ 5 years	12-18 years	No data ~ 4 years
Wear ratio	Faster than enamel	Excessive in occlusal stress areas	Excessive in occlusal stress areas	Similar to the structure of enamel	Similar to the structure of enamel
Fracture resistance	Good to very good	Poor to very good	Poor	Very good	Very good
Marginal integrity (marginal adaptation)	Good to very good Closing the marginal gap with corrosion products	Poor to very good Polymerization shrinkage affects the marginal integrity	Poor to very good, depending on type	Average to good Depending on the adjustment and fixing cement composition	Medium to very good Depending on the adjustment and fixing cement composition
Conservation of tooth structure	Good	Very good	Very good	Poor	Good
Aesthetics	Poor	Very good	Good	Poor	Very good
Patient's age	All ages	All ages	All ages	Adult	Adult
The amount of occlusal stress	Moderate stress	Reduced stress	Class V (adults) and All classes (deciduous teeth)	High stress	Moderate stress
Cavity extensiveness	Initial -moderate	Initial -moderate	Class I and II (children) Initial -moderate	Extensive crown destruction	Average crown destruction
Price	1 X	1.5 X	1.4 X	8 X + gold	3.5 X

material and production technology, dentist's education, equipment and the ability to select the most appropriate treatment. Firstly, the factors influencing the clinical therapeutic choice were determined, and then the material functional properties were analyzed according to available literature, including the analysis of the restoration's longevity and the main causes of its failure. The available types of dental restorations were analyzed and compared between each other; those which solidify directly in the mouth (amalgams, resin-based composites for direct restorations) and those made in a dental laboratory and then placed in a previously designed tooth cavity (resin-based composites for indirect restorations, dental ceramic inlays and crowns) in order to make a conclusion about their advantages and limits which influence a therapeutic choice.

The ideal restorative material should meet certain requirements related to biocompatibility, mechanical, physical, chemical and technical parameters, which serve to increase its efficiency and quality of performance during its exploitation in the oral environment.

The choice of restorative material depends on each clinical case and it is a responsibility of a dentist. There is no currently available materials that meet all the requirements for the ideal material, and each possess its own advantages and disadvantages. The dentist have to be familiar with materials' properties, the good and bad ones, with indications and contraindications for each clinical situation, and to be able to analyze all the present parameters in order to make a final clinical choice which suites each case the best (Alb, 2008; Christensen 2005; Mjör 1989). Currently, a dentist has a wide range of available restorative materials, and most commonly the success of a dental restorative treatment depends on his choice of the most suitable material for each case, and of correct handling with chosen material.

The aim of this study was to analyze the factors influencing a clinical choice of different methods of posterior teeth reconstruction.

Materials and methods

In the context of decision making, the authors intended to establish a set of precise criteria for assessing the therapeutic indications for dental restorations. Hence, the authors created a set of criteria that should guide a choice of a suitable restoration, and studied using of those criteria in the every-day clinical practice. The authors proposed a "decision guide" including the criteria which influence the decision making during a tooth-restorative procedure, which was applied to all clinical cases treated in the authors' dental office for two years. The clinical choices were made in accordance with the mentioned set, and certain exceptions during a final clinical choice creation were analyzed. Besides the composite restoration's absolute predominance among frontal teeth restoratives, the choice of a material for posterior teeth restoration remains difficult and controversial. The crown restoration of posterior teeth can be made out using several available options: direct fillings (amalgam filling, resin-based composites, glass-ionomers), or indirect fillings (inlays or full crowns made of noble alloys, resin-based composites or ceramics), depending on the extensiveness of a tooth destruction. Table 1 summarized the quality assessment of restorative materials according to certain restoration's quality criteria, such as: longevity, wear resistance, fracture resistance, marginal adaptation, indication, aesthetics, conservation of tooth structure, and a price. The choice of the most suitable material is the responsibility of a dentist, who is the one who have to weight all the aspects influencing the restoration quality (Table 1).

Based on those criteria from the literature and based on the practical experience, the authors constructed a decision-guide. Its purpose was to offer a strategy for creating a balanced choice when choosing between different possible restorative options. Summarized, those criteria consist of listed variables: 1) aesthetics, 2) degree of crown destruction, 3) preservation of hard tooth tissues, 4) longevity (including wear resistance analysis), 5) level of caries index, 6) oral hygiene, 7) price, 8) material's handling properties, and a need for a specific restorative technique (including the need for special materials and equipment), 9) secondary caries, 10) influence of patient's age on clinical choice. For each tooth sample for which a diagnosis was defined, a treatment plan was subjected to the analysis based on the "decision criteria" list. All the listed criteria were scored as follows: 0 contraindicated treatment; 1 – a treatment option acceptable; 2 – a good treatment option; 3 - a very good treatment solution (Table 2). The scores 0, 1, 2 or 3 were given for each of the 10 parameters, for each analyzed tooth, in order to establish the optimal treatment plan. Finally, all the scored were summed into a one total score, for each possible alternative treatment, and the highest score was considered as the most appropriate therapeutic choice. Therapeutic solution chosen was discussed with patient, and depending on his possibilities and acceptance, the specific treatment was conducted, or, exceptionally, changed to the compromised one.

Table 2. List the criteria of choice with the accompanying scoring which was applied before each treatment. The presented example of the list was completed with the scores given for the tooth 2.6, with the fractured old amalgam filling, mesio-occlusal II class cavity

No.	The criterion of choice	The given score			
		HG	RBCd	RBCi	CER
1	Aesthetics	0	2	3	3
2	The degree of crown destruction	0	0	2	2
3	The preservation of tooth's hard tissue	0	2	3	2
4	Longevity (including wear resistance)	1	0	2	3
5	Level of caries index	3	3	3	3
6	Oral hygiene	3	3	3	3
7	The price	3	2	1	0
8	The complexity of technique	3	2	2	1
9	Secondary caries	3	2	3	3
10	Influence of patient's age	2	2	2	2
	Total score	18	18	24	23

Finally, the selected choice created using the "decision guide" was compared to the final treatment conducted, which was chosen based on the real situation in accordance with patients' possibilities, and requirements.

The protocol was approved by the Ethics Committee of "Iuliu Hatieganu" University of Medicine and Pharmacy Cluj-Napoca. All patients gave informed written consent to participate.

Results

These criteria were applied to a total number of 105 patients who were subjected to a crown restoration treatment of a posterior tooth. In total, 345 restorations were done: 279 direct restorations (78 amalgams, and 201 composite) in 85 patients; and 66 indirect restorations (41 composite and 25 ceramic inlays) in 20 patients (Table 3).

The distribution of restored classes and corresponding restoration types are shown in Table 3, where written symbols represent as follows: HG - amalgam filling; RBCd – resin-based composite direct filling; RBCi – resin-based composite inlay made in a dental laboratory; CER – ceramic inlay.

Table 3. The distribution of restored classes and corresponding restoration types included in the study

Class	No.		Direct		Indirect	
	Direct	Indirect	HG	RBCd	RBCi	CER
Class I	95	4	23	72	-	4
Class II	184	62	55	129	41	21
Total	279	66	78	201	41	25

From the 345 analyzed restorations, direct and indirect ones were separately analyzed, as follows (Table 4):

a) From the total number of 91 indicated amalgam fillings using the set of criteria, only 78 were finally chosen and placed in the oral cavity, and from the 127 indicated direct composite fillings, all the 127 were done. Only 13 decisions for the indicated amalgam restorations were changed (5.9 % of cases), and replaced with direct composite restoratives.

b) Considering the indicated indirect restorations, the situation was different. After applying the specified criteria set, 127 indirect restorations were indicated, including 72 composite inlays and 55 ceramic inlays. Only 66 of total 127 cases used the specified inlay restoration according to the criteria set (51.9 % cases), and for the 61 cases (48.1 % cases) the decision was changed and the direct composite restoration was used.

Analyzing the performed treatments, it may be concluded that a total number of 74 direct composites served as replacement for the other indications, which were not possible to be done due to any reason. In other words, 30.1 % of all direct composite restoratives were used instead of the other indication, which could not be realized (27 amalgam fillings, 31 composite inlays, 26 ceramic inlays – 57 restorations in total). Consequently, only 57 restorations were actually optimally restored with indirect composite or ceramic restoration, and all the others were a result of a compromise.

As it was shown in Table 4, there were cases in which the treatment indication, set according to the set of criteria and the maximum calculated scores, was not respected. The reasons that changed each restoration's indication were separately analyzed and shown in Tables 5-7.

The most significant difference was observed for the direct resin-based composite restoration, where a significant widening of composite indications was done. Instead of 127 indicated composite cases, the totals of 201 cases were placed (+74 cases).

The opposite trend occurred with respect to inlays. There was a negative trend for the indicated inlays, where a total of 61 cases

were not chosen as a final restoration, despite the criteria set (the indicated composite inlays were replaced with a directed composite restoration, in 57 cases, and the 4 cases of indicated ceramic inlays were replaced with a direct composite). The reasons which changed the indication for the indirect restoration were respectively: the financial reason, level of caries index, poor oral hygiene and the amount of patient's free time.

Table 4. The indicated restorations compared with the applied dental treatments

Restoration type	No. of indications	No. of performed treatments	Difference
HG	91	78	-13
RBCd	127	201	74
RBCi	72	41	-31
CER	55	25	-30
Total	345	345	

Table 5. The causes of the decision change from restorative inlays to direct restorations

Causes	No. of cases
The price	39
Level of caries index	9
Oral hygiene	5
The amount of patient's free time	4
Total	57

Also, there were cases in which the most appropriate treatment solution was an amalgam filling, but the patient refused it for the aesthetic reasons, hence a direct composite restoration was applied. According to the values showed in Table 2, it can be concluded that only 13 amalgam restorations were refused due to aesthetic reasons; but in reality there were a total of 27 cases where patients tried to refuse the amalgam filling; however, after a discussion with patients, in 14 of those cases the final decision was to place the amalgam filling, due to its low cost, longevity and overall advantages for the specific indications.

Table 6. The causes of decision changes from unaesthetic restoratives to the aesthetic ones, and vice versa

Causes	No. of cases	
	Indication: RBCd Treatment: HG	Indication: HG Treatment: RBCd
Aesthetics	-	27
Financial reasons	11	-
Longevity	3	-
Total	14	27

Mostly, the indicated restorations, set using the given criteria and the maximum score obtained were in accordance with the final indication set by dentist (75.7 %). The most common reasons, which influenced the set of criteria, were the financial ones (39 cases of inlays, and 11 cases of direct composites; 50

restorations of 354 in total, i.e. 14.5 % of all indicated restorations were changed with the cheaper options). In other cases the aesthetic criteria influenced the final decision; patients refused the amalgam restorations in 27 cases, and therefore the amalgam choice was changed with a direct composite, in 7.8 %. In a few cases, the patient's lack of motivation influenced the final decision; for example, four of them refused inlay restorations, as they didn't have the time for at least two clinical stages needed for their production (1.1 %).

There were situations where the best treatment solution was the inlay, with respect to the tooth decay extensiveness, but a poor oral hygiene, and a high caries index influenced the inlays to become contraindicated for specific cases (4.05 %)

The most common causes of the change of indication of any treatment were: the price, aesthetics, caries index level, oral hygiene, and the amount of patient's free time (Table 7).

Table 7. The causes of changed decisions from those determined by a maximum score obtained

Causes	No. of cases
The price	39
Aesthetics	27
The level of caries index	9
Oral hygiene	5
The amount of patient's free time	4
Longevity	3

Analyzing the patients' requirements from the gender perspective (71 women, and 34 men), it was noticed that the aesthetics was more important to women, but to men the most important criteria was the price and the time required for specific treatment. Analyzing the requirements of the groups of different age, significant differences between specific groups were noticed. The patients between 31 to 40 years emphasized the importance of their free time, and demanded the adequate duration of a treatment, as well as the importance of the restoration's longevity. The patients aging 20 to 30 were particularly interested in the aesthetics of the restoration (Table 8).

Table 8. The main requirements for crown restoration's properties of patients of a different age

The main requirements	20-30 years	31-40 years	41-50 years	51-60 years
The price	8	-	12	19
Aesthetics	16	5	3	3
Longevity	-	2	1	-
Duration	-	4	-	-
Total	24	11	16	22

Discussion

Depending on the diagnosis, cavity design, amount of occlusal forces and previous tooth pathology, there are different available methods for a crown tooth reconstruction. The choice between the direct and indirect restorations should be made with respect to their positive and negative aspects, the patient's preferences,

oral hygiene and caries index status. Mostly, the patient demands an aesthetic restoration, in the shortest possible time, with a minimal price, at the same time. These demands push the dentist in a relatively difficult position in order to decide whether to make a compromising treatment or not.

The most common example present in the every-day practice is the need for a posterior restoration of extensively damaged tooth, which is at the same time exposed to a high level of occlusal stresses. In these situations, those indications mostly exceed the direct composite filling's properties; at the same time the amalgam fillings are refused by the patients, due to their poor aesthetic appearance, and the indirect composite or ceramic inlays are not well accepted, due to their high price and more treatment sessions required (Marek 1990; Mjör 2005).

The authors tried to include all the critical factors which influence the choice of a restorative procedure, in the created "decision guide". Those criteria are presented and discussed in detail in following paragraphs:

1. Aesthetics. Lately, the aesthetic appearance of a dental posterior restoration came in a first plan, and there is a growing percentage of patients demanding the aesthetics as a main requirement in every-day clinical practice. Over 50 % of all patients put their priorities to aesthetics and physiognomy, and not on the tooth functionality. This causes the more and more demands for aesthetic restorations of posterior teeth, which are sometimes extensively damaged, with deep caries lesions, with large old amalgam fillings, fractured, or compromised in terms of the crown reconstruction possibilities.

2. The degree of crown destruction. The degree of crown destruction is one of the most important criteria influencing the assessment of the most suitable restorative material. The properties of all available materials significantly vary between each other, and every of them has its own advantages and disadvantages, for example: the composites have the good ability to retain to the various cavity shapes, but they are not suitable enough for the high load-bearing areas, where the occlusal forces are too strong, due to their relatively weak wear resistance and fracture resistance; the ceramic inlays have very high compressive strength, and very good wear resistance, but they are weak when exposed to tensile and bending forces, i.e. the high occlusal forces of lateral directions can cause their brittle fracture; the amalgam fillings can replace very extensive defects, but the poorly designed cavity for the amalgam restoration can cause a failure of its retention, or a fracture of a thin tooth wall, when the tooth resistance form was not satisfied.

3. The conservation of tooth's hard tissues. The conservation of tooth's hard tissues is of extreme importance, especially in cases where the tooth destruction is so extensive that a failure of the rest of tooth walls, remained after a caries removal, can occur. The amalgam fillings demand the retention boxes and therefore the more removal of a healthy tooth structure in order to be retained. On the other hand a composite material offers more possibilities for the tooth structure preservation, it can be placed in the adhesively designed, round-walls cavity, and in addition it could serve as a reinforcing material for the rest of the tooth structure (Roulet *et al* 1991). The beveling of tooth cusps is sometimes a necessary procedure for the preservation of the remained tooth structure and prevention of its fracture.

4. The restoration's longevity. The restoration's longevity is influenced by many factors acting simultaneously in the oral environment. The dynamical occlusal forces of various intensity, the presence of bruxism, bad habits, the constants saliva flow, the changeable levels of acidity, different temperature changes, the oral hygiene status, the presence of a biofilm retained, the specific tooth's condition, available materials' properties, all those factors have the effect on the final procedure choice, which should be created with respect of predicting restoration's duration in every specific case.

5. Level of caries index. Caries index level often has a strong influence on the final choice of the restoration, due to its very high potential to cause new caries lesions. Therefore, the composite restorations and the indirect aesthetic restorations are contraindicated in patients with a high caries index level. Glass-ionomers could serve as a good choice for restoring such cases, due to its ability to continuously release the fluorides in the oral environment, helping in prevention of the initiation of marginal secondary caries.

6. Oral hygiene. The level of oral hygiene is very important and affects the clinical success of restorative procedures. If there is not a possibility to implement new and adequate hygiene and preventive measures, the composite materials and aesthetic inlays are contraindicated. The amalgams are the materials of choice in those cases, due to their specific property of releasing of corrosive products and filling the marginal gap between, providing the caries resistance of filling-tooth margins. The glass-ionomers are good restoratives for cavities in an oral environment with a poor hygiene level.

7. The price. The price often becomes a main reason for the material selection, no matter whether a material is the best therapeutic solution for specific case. The compromised therapies caused by the mentioned problem, sometimes are the only solution, but this limitation influence the overall properties and longevity of the restoration.

8. Handling properties and need for additional equipment. There is sometimes a need for additional equipment for specific materials and procedures, which can cause the need for higher investment, and could influence the final price (dual-cured composite cements for cementing aesthetic inlays; the need for a rubber dam; finishing kits for ceramic restorations etc.). The dentist need to create the best investment-benefit situation, in order not to be underpaid, on the one hand, and not to force a patient to change the best possible indicated restorative treatment due to its high cost, on the other hand. Recently, the new technical solutions in prosthetics became available on the dental market, such as CAD/CAM systems, but their price is very high, and they demand well educated teams for their utilization.

9. Secondary caries. The presence of a secondary caries is not a problem of restorative materials itself, but it is caused by a combination between specific oral environment conditions and placed material. The composite material is well known to cause the marginal gap and bad marginal adaptation causing the marginal leakage and the potential of a secondary caries development (Gordan *et al* 2002; Manhart *et al* 2001).

10. The criteria related with patient's age. When choosing the most suitable material for each case, the patient's age have to be taken into account. There are the materials which are the most suitable for a restoration of deciduous teeth, such as glass-ionomer

cements – GIC, and resin-modified glass-ionomer cements – RMGIC, which release fluorides and serve as remineralizing filling materials for the child’s teeth. The indirect restorations are contraindicated under the age of 16. The age criterion was put at the last place of this criteria set, as the authors’ patients were between 17 and 56, and there were no significant differences in restoration procedures regarding their age. In elderly patients, however, the choice of a restoration is sometimes affected with procedure duration, or its complexity, due to their overall health condition.

When a particular restoration is observed, the variety of factors should be taken into consideration. Firstly, the main purpose of any restoration is to aesthetically and functionally rehabilitate the original tooth structure, secondly, to provide a resistance of both remain tooth structures and restoration, and thirdly, to replace the old restorations that are not clinically acceptable (Powers et al 1980; Mjör 1981). The decision about dental restorative replacement depends on either its aesthetic or functional failure, but it is completely dependent on the dentist’s decision and it is highly subjective. For example, there can be met a different treatment plans for the same clinical situation, depending on the dentist who decide and create a plan. It is of great importance to create a general set of criteria necessary for the independent assessing of the most suitable therapeutic plan (Gordan et al 2006; Smalles & Webster 1993).

Conclusion

In this study the authors established a set of objective criteria that should serve as a guide for decision making in order to provide the best therapeutic outcome for each posterior tooth restoration. The study determined the amount of overlapped indicated treatments with those set using the defined criteria, and analyzed the reasons for compromised dental restorative solutions. If there is a need for a change of the best treatment solution with the compromised one, the dentist should carefully consider all the benefits and disadvantages of such a decision, and not to go beyond the obvious limitations of each material and procedure, in order to avoid the functional failure of restoratives.

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