Adhesive Restorations in the Posterior Area with Subgingival Cervical Margins: New Classification and Differentiated Treatment Approach

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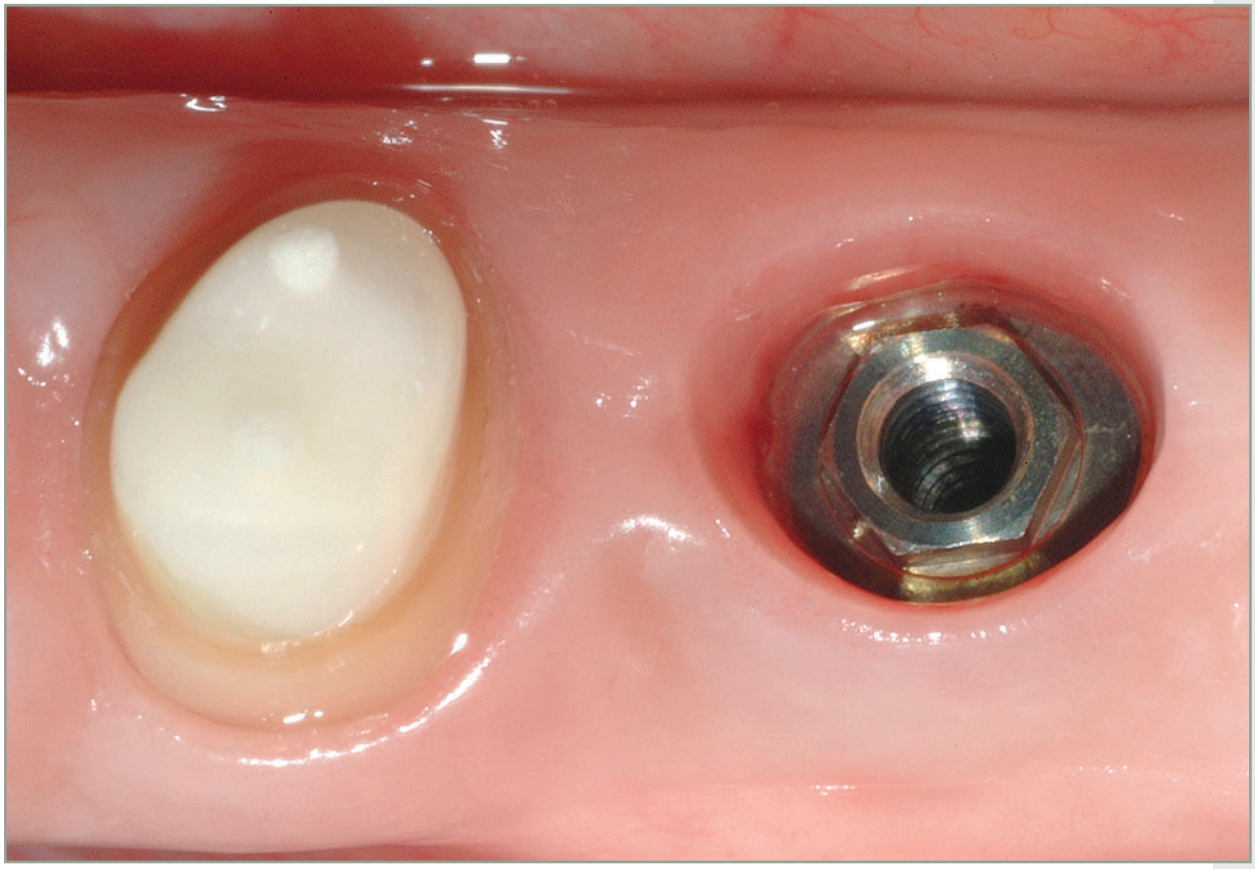

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Abstract

The aim of this article is to analyze some of the issues related to the adhesive restoration of teeth with deep cervical and/or subgingival margins in the posterior area. Three different problems tend to occur during restoration: loss of dental substance, detection of subgingival cervical margins, and dentin sealing of the cervical margins. These conditions, together with the presence of medium/large-sized cavities associated with cuspal involvement and absence of cervical enamel, are indications for indirect adhesive restorations. Subgingival margins are associated with biological and technical problems such as difficulty in isolating the working field with a dental dam, adhesion procedures, impression taking, and final positioning of the restoration itself.

A new classification is suggested based on two clinical parameters: *1)* a technical-operative parameter (possibility of correct isolation through the dental dam) and *2)* a biological parameter (depending on the biologic width). Three different clinical situations and three different therapeutic approaches are identified (1st, 2nd, and 3rd, respectively): coronal relocation of the margin, surgical exposure of the margin, and clinical crown lengthening. The latter is associated with three further operative sequences: immediate, early, or delayed impression taking.

The different therapeutic options are described and illustrated by several clinical cases. The surgical-restorative approach, whereby surgery is strictly associated with buildup, onlay preparation, and impression taking is particularly interesting. The restoration is cemented after only 1 week. This approach makes it possible to speed up the therapy by eliminating the intermediate phases associated with positioning the provisional restorations, and with fast and efficient healing of the soft marginal tissue.
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Introduction

From the mid 90s onwards, materials and adhesive techniques have evolved considerably and have led to changes in the restorative approach to the posterior area, and in the treatment plan.[1] The need to carry out composite restorations in the posterior area is not only for esthetic reasons but primarily concerns the principle of bioeconomics (maximum conservation of healthy tissue) and of "reinforcing" the residual dental structure.[2] The most suitable materials for this type of restoration are microhybrid or nanoparticle composites as, being densely filled, they have excellent physical-mechanical properties, are radiopaque, have an elasticity module similar to dentin, and have a resistance to wear that is comparable to enamel and amalgam (10.30 μm/year). For these reasons, they are suitable for all types of cavities.[3] If used correctly, the new materials and adhesive techniques available today can guarantee excellent, long-term results.[4,5]

There are, however, some problems that have yet to be completely resolved and these are linked to polymerization contraction and dentinal adhesion, primarily in major reconstructions using a direct technique. Such problems have led to the development of semi-direct and indirect approaches incomposite restorations where everything is completely cured before it is cemented into the cavity.[6]

An adhesive approach allows dental structures to be maintained even when not completely supported by dentin and to preserve the vitality of teeth in cases where traditional metallic techniques would require root canal therapy in order to use the pulp chamber in a retentive capacity. The result is an esthetically and functionally well-integrated conservative restoration that can be retreated at a later date, either endodontically or for reconstruction.[7]

Therefore, as the "therapeutic arsenal" for rehabilitation in the posterior areas has changed, there is now an overall prevalence of adhesive restorations and their different application techniques (direct, semi-direct, indirect). Silver amalgam is no longer indicated, except in certain clinical applications. Gold onlays maintain their effectiveness in cases of minimum inter-occlusal spaces (gold being the only material with the physical-mechanical properties suitable for thicknesses less than 1 mm) or in parafunctional patients. The number of single elements requiring prosthetic restoration has been considerably reduced and therefore the line between conservative treatment and replacement has changed. Finally, with regard to seriously affected teeth, the development of implant techniques and evidence regarding osseointegration and guided bone regeneration (GBR) processes sometimes makes implant-prosthesis treatment more predictable compared to restoration.

In the present study, the main objectives of reconstructive treatment remain unchanged and they are the following:

- restore correct biologic width in relation to the positioning of the restoration, conservation, or prosthetic margins. It is important to underline that, in the case of adhesive restorations, cervical banding (a fundamental requirement for prosthetic restorations) is unnecessary. However, an adequate distance between the cervical cavity margin, correctly cleansed of decay, and periodontal attachment, must be restored. This inevitably leads to a more conservative type of resective surgical approach.

- re-establish correct occlusal function, which means that restorations are able to provide stability to the occlusion itself in the absence of pre-contacts and/or lateral and protrusive interference
- restore the morphological and, if possible, esthetic integrity of the tooth
- guarantee excellent coronal marginal sealing, which is absolutely necessary for the lifespan of the restoration itself, but also for the conservation of an apical seal.

Restoration problems

Second class restorations with deep cervical margins generally entail three different problems in the restoration phase:

- substantial loss of dental substance
- subgingival cervical margins
- partial or total sealing of the cervical margins in the absence of enamel (with dentin and cementum).

In the above situations, there are two different clinical problems: biological (ie, the relationship with marginal periodontal tissues), and technical-operative problems such difficulty in isolating the operative field by means of the dental dam, adhesion procedures, impression taking, and successive phases of adhesive cementing, finishing, and polishing.

These problems will be analyzed in order to formulate a clinical classification of the different situations and related differentiated therapeutic approaches.

Significant loss of dental substance

According to the classification compiled by the school of Geneva in 1994,[1] composite resins can be used in the posterior areas with different techniques: direct, semi-direct, and indirect. The choice of technique is dictated by the following parameters:

- general; such as oral hygiene, susceptibility to decay, parafunctions, age, esthetic requirements, and economic means
- local; such as cavity shape and dimensions, number of restorations, margin positions, quantity of residual cervical enamel, and position of tooth in the arch.

Direct techniques are indicated for Class I and Class II preventive restorations of small or medium dimensions with the presence of cervical enamel. It is evident that the above conditions are rarely found in carious lesions which extend to the subgingival level. As a rule, the latter cases are associated with cavities of wide dimensions, often with the need for cuspal coverage with consequent problems relating to contraction stress. Polymerization contraction, in fact, is linked to the conversion of monomers to polymers in a network structure, with consequent decrease in volume. The effects of polymerization stress are evident at two levels: *a)* in relation to the cavity, with possible distortions or micro-fractures of the walls themselves; and *b)* at marginal interface adhesive level (with consequent micro-infiltration), or internal (with consequent compression hypersensitivity).[8] To counteract polymerization contraction and improve marginal adaptation of Class II restorations, various procedures have been suggested (use of terminals for condensation-polymerization,[9] positioning of glass or ceramic

inserts,[10] use of bases in glass ionomer cement), while polymerization segmentation[11] by means of multi-layered techniques (horizontal, oblique, four increments) is particularly efficient. However, these techniques are not considered efficient enough for application in cavities of large dimensions with possible cusp coverage, where a major compensation for immediate polymerization stress is necessary, unlike spontaneous post-polymerization which continues for several days after insertion of the composite.[12] In these conditions (cavities of large dimensions, cusp tip, reduced thickness of cervical enamel), adhesively cemented restorations are indicated using semi-direct or indirect techniques.[7] The fundamental advantage of these cemented techniques is the possibility of reducing the polymerization contraction of the material, which occurs outside the cavity, to a maximum with consequent benefits for marginal adaptation. The only residual polymerization contraction, which is not very significant, relates to the thin layer of resin used for cementing.[13] Moreover, post-polymerization with photothermic treatment of the manufactured part improves the degree of conversion and, as a consequence, the physical-mechanical properties of the restoration (wear resistance[14] and dimensional stability[15]). Other advantages of such methods include the possibility of ideal anatomic modeling and occlusal rehabilitations verified with an articulator.

It is obviously important to evaluate wear resistance and average duration of restorations in order to decide which technique to use for wide restoration of dental elements with the covering of one or more canines.

An analysis of international publications shows encouraging data regarding composite material wear: after five years wear equal to 13.2 μm/year;[16] average wear 12 to 15 μm/year;[17] wear supersedes enamel and amalgam;[18,19] a 17-year study showed average wear of 15.5 μm/year.[20] Finally, Ferracane et al in 1996 stressed how the degree of wear is linked to the volume percentage of the filler, the resin-filler bonding, and the conversion level of the polymer.[21]

In any case, a bibliographical search in PubMed from 1970 to 2004 shows that 6,521 articles have been published on the problem of wear, a sign that the problem is not easily interpreted.

Similarly, published data concerning composite restoration longevity are also encouraging: Skeeters et al,[22] after 15 years, 95% of adhesive restorations maintained their function; Kohler et al,[23] the 5-year duration was due to correct selection of cases and cario-receptiveness; Wassel et al,[24] after 5 years, 17% of failures were inlay restorations and 8% were direct composite ones; and Van Dijken,[25] after 11 years, composite onlays using intraoral techniques survived in 83% of cases. Similar data can also be seen in the 11-year random longitudinal clinical study by Pallesen and Qvist:[26] direct composites presented a failure rate of 16% and inlay restorations 17%, with an annual failure rate of 1.5%. An important review of the clinical longevity of direct and indirect restorations in the posterior area after 15 years was published by Manhart et al,[4] which reported the following data on the average annual failure rate: 3% amalgam, 2.2% direct composites, 2.9% composite onlays, 1.9% ceramic restorations, 1.7% CAD-CAM ceramic restorations, and 1.4% gold onlays. Finally, Opdam et al[5] published a retrospective clinical study on 1,955 composite restorations of dental elements in the posterior area, with a

longevity rate of 91.7% after 5 years and 82.2% after 10 years.

Published data aside, it can be affirmed with reasonable certainty that the predictability of success and therefore the longevity of restorations are closely connected with accuracy in the implementation of procedures as well as compliance with protocols and indications. The importance of the "operator factor" has been previously reported.

Partial or total cervical margin sealings in the absence of enamel (in dentin and cementum)

Frequently, cavities of large dimensions extend beyond the cementoenamel junction with margins more or less deeply located in the gingival tissue and with little or no residual enamel. While adhesion to mordant-treated enamel is predictable and safe, adhesion to dentin and cementum is dependent on numerous and complex phenomena. The formation of an efficient hybrid layer is influenced by many clinical steps (etching, drying, primer application, bonding application), including the polymerization of adhesive resin that stabilizes the structure of the hybrid layer itself. However, a problem with the lasting stability of the adhesion exists.[27,28]

As already highlighted, indirect adhesively cemented restorations are suitable in the above conditions. These require a cavity of adequate configuration and shape with smooth and well-defined divergent walls, clean rounded internal angles, bevel-free butt enamel finishing, and a location above gingival margins.[7] The application of a base is necessary to satisfy several of these requirements. It is important to preserve as much residual healthy tissue as possible and obtain a thin smooth layer of adhesive cement by means of a buildup in order to control contraction stress during cementing.

In cases with slightly subgingival margins, it is possible to relocate the cervical preparation to above gingival levels by applying an appropriate increment of composite resin over the pre-existing margin. This is known as "coronal margin relocation" and was first proposed in 1998 by Dietschi and Spreafico[29] to simplify the clinical procedures of adhesive cementation. The technique represents—in some specific cases—a non-invasive alternative to surgical crown lengthening.

The operating procedure was then defined by means of an *in vitro* study by Olsburgh[30] and establishes the following: rigorous isolation of the field with a dental dam, positioning of a matrix to guarantee a cervical seal, thorough cleansing of the cavity finishing with a bicarbonate spray, adhesive phase with a three-step etch-and-rinse method, and raising of the cervical step with flowable composite of maximum 1 mm thickness. Following this protocol, 98% of margins obtained by the author were excellent.

As mentioned above, the technique requires the use of flowables. Flowables are composites of low-viscosity, due to the reduced volume of inorganic filling particles (44 to 55%). As they contain a higher quantity of resinous components, they present higher volumetric contraction but lower stress contraction: they have a low Young's module (3.6 to 6.7 GPa) and therefore a higher level of elastic deformation and intrinsic internal flow capacity. The importance of incorporating an elastic layer in the

buildup has been emphasized by various authors, including Kemp-Scholte and Davidson,[31] in order to make up for the contraction stress and act as a stress absorber. It is now a common procedure, both in direct and indirect restorations.

However, the use of the flowable as a first increment for the cervical step is controversial; several authors[32-35] maintain that there is no significant trend in the reduction of micro-leakage in Class II restorations when a thin layer of flowable composite is applied under restoration composite. A higher number of authors[31,36-42] maintain that when flowable is applied as the first cervical increment in Class II restorations, gingival micro-leakage is reduced and marginal integrity is improved. In particular, in an article by Dietschi et al,[39] the authors clearly suggest that the use of a medium-rigid flowable composite (7.6 GPa) is a potentially valid material to displace, in a coronal position, proximal margins under composite inlays.

In the absence of reliable scientific evidence, but on the basis of published data and clinical experience, the importance and the systematic use of flowable composite—at the cervical level in the absence of enamel—can be supported according to the following rationale:

- interposition of an "elastic layer" of controlled thickness (0.5 to 1 mm) between the dental substratum and restoration material. This allows contraction stress to be absorbed and the adhesive interface to be preserved.[8,31,38,43]
- fluid adaptation to the cavity floor with absence of blisters and visual control of the cervical seal prior to correct positioning of matrix and wedge
- straightening of the cervical margin as a result of burring
- immediate dentin sealing: it seems that dentin adhesive improves bonding strength if it is applied to dentin prepared immediately beforehand[44]
- protection of the adhesive film: all simplified adhesives, and to a lesser extent even the etch-and-rinse adhesives, act as semi-permeable membranes allowing oozing of dentinal fluid and consequent loss of complete adhesive efficiency[45]
- composite-composite adhesion is possible and efficient if carried out within 30 days,[46,47] but in the specific case of onlays, the final cementing is carried out in 7 to 10 days.

It is clear that all adhesive procedures must be strictly carried out in an isolated field. The isolation of the field by means of a dental dam protects the restoration from contamination by saliva, blood, gingival crevicular fluid, breath moisture and increases the comfort of both patient and operator. Moreover, it has been reported that dental surfaces are contaminated by a salivary organic film which creates a very low surface tension (28 dynes/cm^2) and prevents adequate wetting of the adhesive with consequent absence of bonding.[48] Therefore, the use of a dam is an unavoidable and integral phase of treatment.

Subgingival cervical margins

The final restoration issues concern the relationship with soft tissue and therefore the frequent presence of subgingival margins.

A retrospective clinical analysis on adhesively cemented restorations carried out

by the author during an observation period from 2000 to 2006, has brought to light much data, as yet unconfirmed by other scientific studies, but interesting from a clinical point of view.

A total of 524 onlays were carried out, of which 124 were on premolars (23.7%) and 400 on molars (76.3%). An inlay restoration was used in 65 elements (12.4%), onlay in 269 elements (51.5%), and overlay in 190 elements (36.2%).

In total, 335 (64%) of the treated elements were live tissue and 40 (12%) underwent surgical lengthening of the clinical crown. A total of 189 (36%) teeth were treated endodontically (devitalization and root canal treatment). Of the endodontically treated teeth, 61 (32.2%) underwent lengthening of the clinical crown.

In conclusion, the highest percentage of onlay restorations was carried out on molars. Of these, 88% of cases were restorations of large dimensions with partial or total cusp coverage. Despite this, in a high percentage of cases (64%), it was possible to maintain the vitality of the elements in keeping with modern principles of the bioeconomy of hard tissues and pulp. Finally, it is interesting to note that in nearly 12% of live teeth and in more than 32% of teeth treated endodontically, a lengthening of the clinical crown was necessary to expose deep cervical margins in subgingival positions.

It is clear that the topic of discussion gains particular importance from a clinical point of view. A treatment strategy with restorations that are correctly integrated with the marginal periodontal tissues requires adherence to the following universally recognized principles:

- restoration of periodontal health by means of correct initial preparation
- restoration of a correct biologic width, wherever this has changed due to the processes of decay, coronal fractures, or pre-existing inadequate restoration margins in subgingival positions, to make the margins easily accessible for conservative treatment or impression taking in the case of indirect restorations
- accuracy in carrying out restorations in the preparation, finishing, and polishing stages
- adequate hygienic aftercare both at home and in the dental clinic.

From the historical studies of Gargiulo et al,[49] the average values of dentogingival junctions are known: sulcus 0.69 mm, junctional epithelium 0.97 mm, connective attachment 1.07 mm with a total biological dimension (epithelial + connective attachment) of 2.04 mm. It must be stressed that the above-mentioned values are average ones and can vary greatly, especially the epithelial attachment.

Studies on animals and clinical and histological observations of human teeth[50,51] have widely demonstrated that periodontal health is jeopardized by gingivitis and loss of attachment associated with submarginal restorations. Flores-de-Jacoby et al[37] has demonstrated on humans that the presence of subgingival margins can lead to an increase in bacterial plaque, gingival indices, and probing depth with immediate development of more aggressive bacterial morphotypes.

Therefore, in the presence of subgingival cervical margins due to deep carious lesions, coronal fractures or prosthetic reoperations, it is absolutely necessary to reestablish an adequate biologic width by surgically lengthening the clinical crown. Surgical lengthening of the clinical crown

can be carried out in three ways:[53] *a)* gingivectomy (resetting of the margin without resetting the clinical attachment), *b)* apical positional flap (APF) (resetting of the margin and resetting of the clinical attachment), and *c)* APF with bone resection (resetting of the margin with removal of supporting bone).

It is clear that the gingivectomy and APF without bone reduction are limited techniques as bone removal is very often necessary to create an adequate distance between the bone crest and the planned restoration margin, depending on the biologic width. The method most commonly used therefore, is the creation of a vestibular flap of double mixed thickness and a palatine flap of total thickness with adequate resecting bone surgery and apical positioning on or slightly above the crest of tissues with vertical mattress sutures to the periosteum. Numerous authors have suggested surgical removal of periodontal support so as to create a distance between the planned restorative margin and the level of the newly modeled bone crest equal to 3 mm[54] or 2.5 to 3.5 mm[55] of exposed tooth. These exposed dental structure figures are considered suitable to receive a new gingival unit formed by the regrowth of supercrestal soft tissue that will proliferate coronally during healing, and to leave a sufficient quantity of dental tissue to complete the restorative procedures.[56,59] The most commonly accepted minimum distance between the bone crest and final restorative margin is 3 mm and assumes an average of 1 mm of supercrestal connective attachment, 1 mm of junctional epithelium, and 1 mm of sulcus depth, even though considerable individual variations should be taken into account.

Finally, an important and significant element is the post-surgical "timing" of wound healing, depending on the successive restorative phases.[58] Wound healing in the tooth-tissue interface progresses according to a predictable sequence.[59,60] The epithelium cells at the wound margin start to migrate within 12 hours and progress by 0.5 to 1 mm/day, and within 2 weeks a new junctional epithelium is formed, even though it is not strong enough to withstand restorative operations that involve the gingival margin. The formation and maturation of the underlying connective attachment require more time. Within a week the space previously occupied by the blood clot is substituted by immature granulation tissues, and at 2 weeks immature connective tissue is formed which is low in collagen. At 8 weeks, the surgical site has a mature junctional epithelium and a connective attachment which are incorporated in the new cement. Therefore, the tissue should be adequate to sustain the trauma connected with restoration procedures involving the gingival margin. From 8 weeks to 6 months, the connective attachment matures with a change in the predisposition of the collagen fibers from parallel to perpendicular to the radicular surface. In esthetic areas with prosthetic restorations, it is advisable to wait 5 to 6 months after surgery so as to have attained margin tissue stability.

New classification of adhesive restorations with subgingival cervical margins

The classification is based on clinical evidence. Isolation of the field with dental dam and compliance with the biologic width

when carrying out adhesive restorations are clinically evident and widely described in the literature, facts that have been fully discussed.

The proposed classification is therefore based on two decision-making parameters in clinical order:

1) technical-operating parameter: possibility of a correct isolation of the field with rubber dental dam
2) biological parameter: measuring the distance between the cleansed cervical margin and periodontal attachment, or the bone crest, with a periodontal probe and radiography.

Using the above parameters, three different clinical situations can be identified and defined according to their importance in three grades:

- Grade 1: the rubber dam, correctly sheathed in the sulcus, is sufficient to show cervical margin with an adequately prepared cavity.
- Grade 2: the rubber dam does not allow a correct isolation of the field but the biologic width is respected (distance between margin and connective attachment > 2 mm, or between margin and bone crest > 3 mm). This situation is made possible by the fact that in the posterior areas, particularly in patients with a thick periodontal biotype, the gingival sulcus sometimes presents a probe depth of at least 3 mm.[61]
- Grade 3: the cavity cervical margin (following carious lesions or coronal fracture) is subgingival with violation of the biologic width (distance between margin and connective tissue attachment < 2 mm, or between margin and bone crest < 3 mm).

Differentiated therapeutic approach

A differentiated therapeutic approach corresponds to the three different clinical situations above:

- Grade 1: coronal relocation of the margin using flowable composite with a maximum thickness of 1 to 1.5 mm, followed by buildup, preparation, and impression. Adhesive cementing of the onlay after 7 days.
- Grade 2: surgical exposition of the margin using flowable composite of 0.5 mm thickness at the cervical margin level followed by buildup, preparation, and immediate impression. Adhesive cementing of onlay 7 days after removal of the sutures.
- Grade 3: surgical lengthening of the clinical crown using three different operational sequences depending on different clinical situations: *a)* immediate impression, *b)* early impression, and *c)* delayed impression.
  - 3a) surgical crown lengthening, positioning of the rubber dam, flowable composite at cervical level of 0.5 mm controlled thickness followed by buildup, preparation, and immediate post-surgical impression. Adhesive cementing after 7 days, immediately after removal of sutures. Approach generally adopted in cases of single vital teeth or those already treated endodontically.
  - 3b) surgical crown lengthening and pre-endodontic reconstruction in first appointment canal therapy in a second appointment, and then early impression taking at 3 weeks (time needed for re-epithelisation of tissues[41]), subject to positioning of dam,

flowable composite at cervical level of 0.5 mm controlled thickness followed by buildup and preparation for onlay. Adhesive cementing after 7 days. Approach generally adopted in cases of single elements where necessary endodontic treatment has not yet been carried out.

- 3c) surgical crown lengthening, temporary reconstructions (pre-endodontic) in glass ionomer cement with impression delayed for 8 to 12 weeks (time needed for maturation of the tissues), subject to positioning of the dam, flowable composite at cervical level of 0.5 mm controlled thickness followed by buildup and preparation for onlay. Adhesive cementing after 7 to 10 days. Approach generally adopted in cases of multiple restorations, quadrant rehabilitations, or complex cases with possible prosthetic treatment of several elements.

It is important to emphasize that—irrespective of the operation sequence used—when the tissues have matured and healed, the boundary between tooth and restoration at the cervical level may be slightly inter-sulcular, but it must be reachable and easy to clean with dental floss in daily oral hygiene routines at home.

Clinical cases of the proposed classification

Adequate clinical documentation is supplied to support what has been said in relation to the proposed classification, with a close examination of the clinical aspects and the operational sequences peculiar to each therapeutic approach.

Case 1 - Grade 1) Coronal margin relocation

A 36-year-old patient (teeth 45, 46, and 47) presented inappropriate gold restorations with traces of further inadequate work (Fig 1a). After removal of the restorations and careful removal of the decayed tissues, cavities of very large dimensions with unsupported walls remained (Fig 1b). With a modern adhesive approach, it was possible to rehabilitate these elements without resorting to prosthetic treatment, while maintaining their vitality. It was evident that indirect cusp coverage restorations were required. In spite of the high level of destruction and the partial or total lack of interproximal cervical enamel, the correctly sheathed dam made it possible to evidence the margins and position matrices which suitably adhered to the cervical profile. This also made it possible to carry out the adhesive phases and the subsequent reconstructive clinical phases in complete safety.

Under these conditions, a coronal relocation of the margins was carried out, using flowable composite 1 to 1.5 mm thick at cervical level and 0.5 mm thick to completely line the remaining part of the dentinal cavity (Fig 1c). The buildup was then completed in composite and preparations were made for overlay (teeth 46 and 47) and onlay (tooth 45) (Fig 1d). A precision impression was taken and the laboratory supplied the parts to be cemented (Fig 1e), which needed to be carried out, if possible, after 7 days. The onlays were tried before isolation of the field and adhesive cementing was conducted using the dam (Fig 1f). The final result shows correct integration of restorations after finishing and polishing from a morpho-functional and esthetic point of view, as well as a good response from marginal tissues (Fig 1g).

Fig 1 Quadrant 4: **(a)** inadequate gold restorations with evidence of recurrent decay and inadequate composite patch work, **(b)** teeth 45, 46, and 47 with cleansed cavities of ample dimensions with unsupported walls and deep cervical margins with enamel reduced or absent at the interproximal level (the dental dam allows correct isolation of the field), **(c)** positioning of the matrices and coronal relocation of margins with flowable composite of thickness 1 to 1.5 mm, **(d)** preparations for onlay of tooth 45, and overlay of teeth 46 and 47, subject to layered buildup, **(e)** composite onlays carried out with indirect technique, **(f)** adhesively cemented restorations, and **(g)** final rehabilitation with suitable morphofunctional and esthetic integration, and good marginal tissue response.

Case 2 - Grade 2) Surgical exposition of the margin and immediate impression

A young patient presented unsuitable restorations (teeth 37, 36, and 35) (Fig 2). The field had to be isolated and the fillings and decayed tissue of the two molars were removed. Large cavities were left with partially sustained walls. The cervical margins presented an adequate quantity of enamel above the gingival margin on the mesial surface of teeth 46 and 47, while the distal margin of tooth 46 presented reduced or absent enamel, partially subgingival, and a correct isolation of the field was problematic (Fig 3). The dam was therefore removed and by means of a periodontal probe, a margin to connective tissue attachment distance of >2 mm could be seen. Therefore a "surgical exposition of the margin" was conducted by means of a chamfered flap with removal of a wedge of soft inter-dental tissue to allow for a correct operating procedure in the successive clinical phases (Fig 4).

It is particularly important to stress how in this phase, without the use of burrs, liberating the supercrestal connective tissue attachment by planing up to the crest from the exposed root and consequent removal of the cement, a spontaneous remodeling of the bone crest was unavoidable, and is described in dental publications as varying between 0.2 to 1 mm, average 0.5 to 0.6. The flaps were repositioned in the crest with a simple interrupted suture and thus, when the dental dam was repositioned, the dentin was "lined" with flowable composite. After buildup, preparations for onlay were defined (Fig 5). At this point, an immediate post-surgical impression was made (Fig 6). The correct impression outline was made possible by vasoconstriction induced by the anesthetic, by precision in sculpting the tissue in order to reduce bleeding and by the correct supragingival position of the now exposed margins. After 7 days, immediately after the removal of the sutures, the adhesive cementing of indirect composite restorations (Figs 7 and 8) was completed. It can be seen that besides a good aesthetic and morphological integration, a rapid and favorable healing and maturation of the tissues was evident after 4 months (Fig 9).

Fig 2 Quadrant 3, initially with a need for re-treatment of teeth 35, 36, and 37.

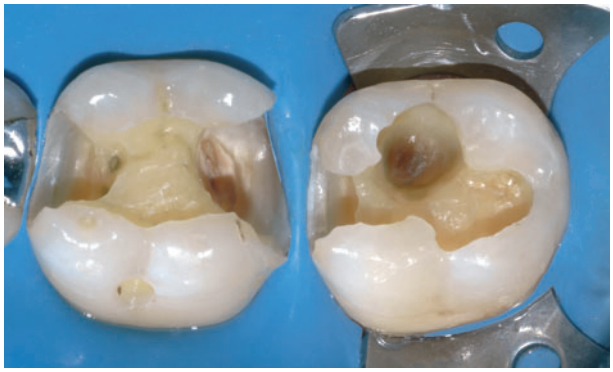


Fig 3 Molar cavities after removal of restorations and cleansing of lesions. The distal margin of tooth 46 is in a partial subgingival position, creating problems for correctly isolating the field.

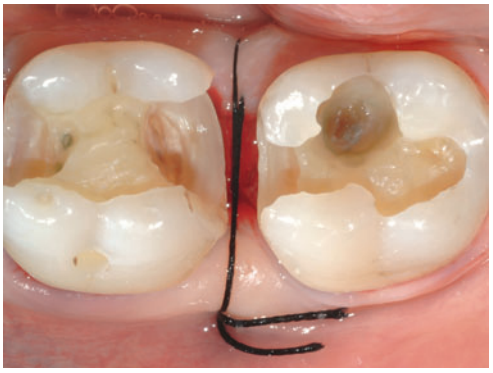


Fig 4 Surgical exposition of the distal margin of tooth 46 by means of internal chamfered flap and removal of a wedge of soft tissue.

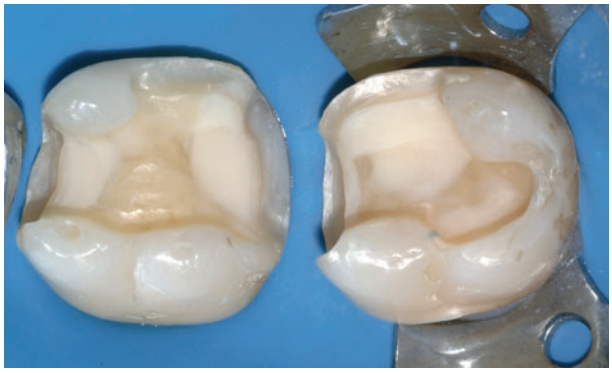


Fig 5 Positioning of the post-surgical dam, buildup, and definition of preparations for onlays.

Fig 6 Immediate post-surgical impression.

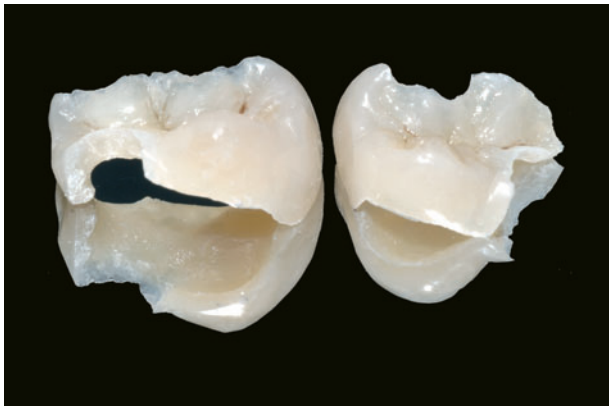


Fig 7 Composite onlays carried out in the laboratory.

Fig 8 Adhesive cementing of restorations.

Fig 9 Control after 4 months with evident tooth–tissue integration.

Case 3a - Grade 3a) Surgical crown lengthening with immediate post-surgical impression

Tooth 26 presented inappropriate amalgam restorations with evident marginal carious infiltrations, due also to a fracture of the filling at the distal level (Fig 10). The bitewing radiograph clearly revealed the presence of carious recurrence. The damage was very near the pulp and deeply involved the distal cervical step (Fig 11). Once the dam was positioned, the old filling was removed and after an initial cleansing of the decayed tissue, the dental dam no longer sealed at the cervical step level (Fig 12). This clinical sign, together with the periodontal probe and radiographic examinations indicated a restoration procedure only after the recovery of the biologic width of the tooth. The clinical crown was surgically lengthened by means of a mixed double V flap and reduced P. An ostectomy and osteoplasty were performed with a palatine "ramp", recreating a positive scalloped edging of the bone crest (Fig 13).

Once a width of nearly 3 mm from the distal conservative margin had been restored and carefully cleansed of decay, a vertical mattress suture was carried out on the bone crest and anchored to the periosteum with crestal positioning of the flaps (Fig 14). Immediate post-surgical positioning of the dental dam was conducted, which now allowed correct isolation. The cavity was prepared, with evaluation of the residual thicknesses and consequent removal of unsupported tissue. Matrix and wedges, to guarantee correct marginal sealing, were positioned. The next step was the adhesive phase and the dentin was completely coated with a 0.5 mm, thin, even layer of flowable composite. The mesial cervical margin presented a good quantity of enamel, which was left "free and clean."

Once the layered buildup in composite had been carried out, the final preparation for onlay was defined (Fig 15). When the dam was removed, making the most of the vasoconstriction induced by the anesthetic, a precision silicone, postoperative impression was taken immediately with a Check-Bite tray according to a monophase dual-arch method.[62]

After a week, the sutures were removed and the onlay in composite was tried using the indirect method was tried (Fig 16). The onlay was then cemented according to a strict protocol.

The final restoration showed suitable marginal adaptation and good morphological, functional, and esthetic integration. Moreover, the positive response of the soft marginal tissues is evident, as they show signs of rapid healing only 20 days after surgery: this is one of the most interesting aspects of the method proposed (Fig 17).

A radiographic check at the end of the procedure is very important to check for any residual excess of composite cement (Fig 18).

Case 3b - Grade 3b) Surgical crown lengthening with early impression at 3 weeks

An 18-year-old patient presented a serious and destructive symptomatic carious lesion on tooth 16. It could be seen clinically and radiographically that the pulp was involved and there was a subgingival position of the distal surface of the tooth with violation of the biologic width (Figs 19 and 20). As a result, endodontic treatment and periodontal surgery were necessary.

Fig 10 Amalgam restorations of a maxillary molar with signs of carious infiltrations and fracture of the distal box.

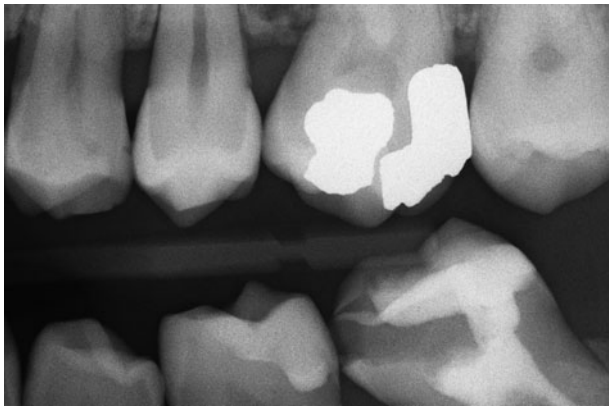


Fig 11 Bitewing radiograph shows the presence of a lesion near the pulp which deeply involves the distal cervical step.

Fig 12 The dental dam, after removal of fillings and cleansing of caries, clearly does not allow an adequate isolation of the distal cervical step.

Fig 13 Lengthening of the clinical crown with bone resection (removal of supporting bone).

Fig 14 Crestal positioning of flaps with sutures anchored to the periosteum.

Fig 15 Immediate post-surgical positioning of the dental dam, removal of unsupported tissue, buildup, and definition of the cavity shape and design for onlay.

Fig 16 Trying out the onlay after one week, contextually, with the removal of the sutures and successive adhesive cementing.

Fig 17 The recall 3 weeks after the operation shows a rapid and favorable healing of the tissues.

Fig 18 Final radiograph shows marginal adaptation and re-establishment of an adequate biologic width.

Being unable to isolate the field with a dental dam, the first phase of the treatment plan required a resective surgical approach (Fig 21) to re-establish a distance of at least 3 mm between the cervical margin, which had been carefully cleaned of the carious lesion in the preoperative phase, and the bone crest.

After the flaps had been sutured with vertical mattress sutures (Fig 22), the postoperative positioning of the rubber dam, the pulpotomy to avoid painful symptoms, and the pre-endodontic reconstruction in glass ionomer cement, the patient could be discharged with a provisional restoration, correct sealing, and contact point. In the next appointment, which should preferably be 7 to 14 days later, root canal treatment was carried out in an isolated field with references for endodontic stops.

Three weeks after the surgical lengthening—the time necessary for canal treatment to prevent bacterial colonization of the endodontic space and allow for re-epithelialization of the periodontal tissues—the adhesive buildup was performed in composite under rubber dam, by removing the provisional reconstruction and applying a layer of flowable composite at a controlled thickness of 0.5 mm (Figs 23 and 24). Preparation was made for a total cusp coverage onlay (Fig 25) and a precision impression was taken. The onlay was manufactured in the laboratory and was adhesively cemented a week later (Figs 26 and 27).

A restoration of correct morphology, emergence profile, interproximal contact points, and well-finished and well-polished margins with an absence of solutions of continuity to control plaque is essential for the longevity of the restoration and for the correct maturation of the periodontal marginal tissues.

Fig 19 Serious and destructive symptomatic carious lesions of the 1st maxillary molar.

Fig 20 Apical radiograph shows the involvement of pulp and violation of the biologic width.

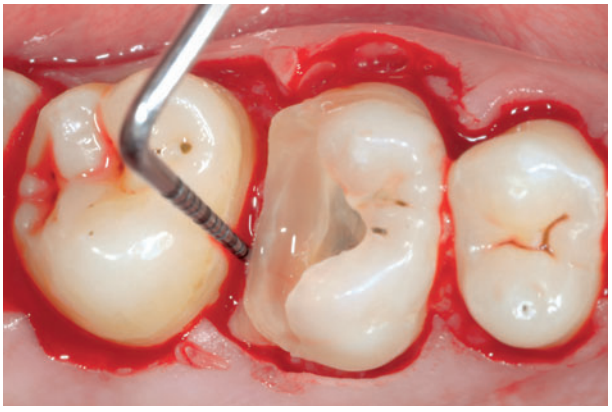


Fig 21 Bone resection as first treatment phase.

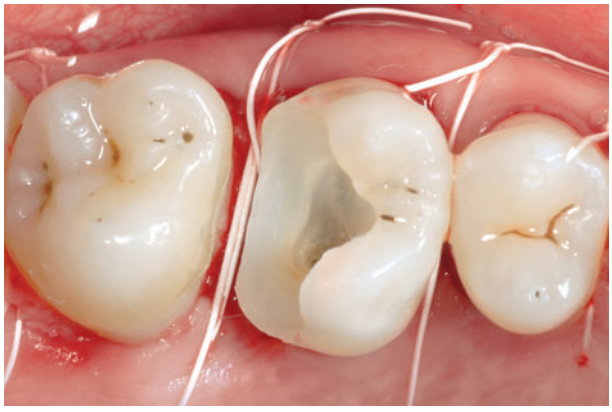


Fig 22 Crestal positioning of flaps and mattress sutures.

Fig 23 Cavities after removal of decayed tissue and endodontic treatment.

Fig 24 Application of a flowable composite layer in a controlled thickness of 0.5 mm.

Fig 25 Preparation for total cusp coverage onlay.

Fig 26 Composite overlay manufactured in the laboratory.

Fig 27 Final adhesively cemented restoration.

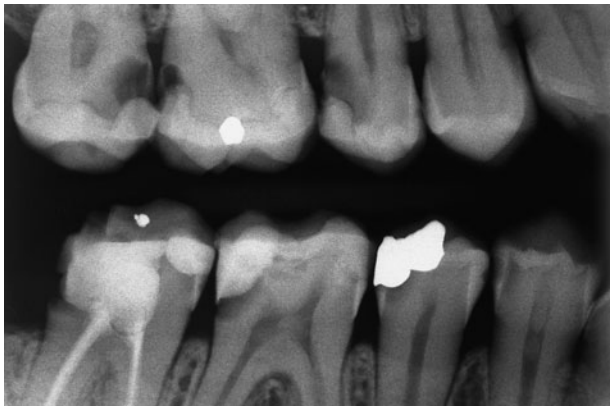
Case 3c - Grade 3c) Surgical crown lengthening with delayed impression at 8 to 12 weeks

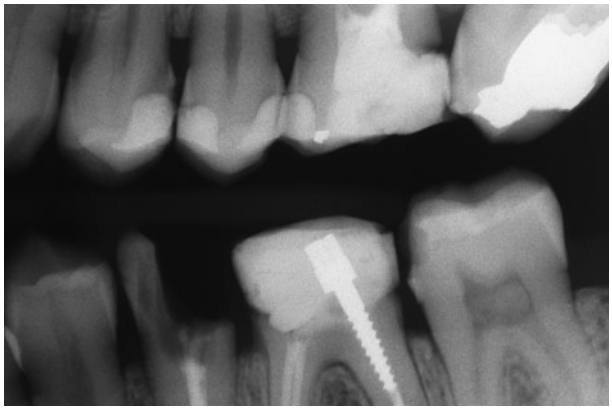
In cases of complex conservative rehabilitations when it is necessary to intervene on one or more quadrants contemporarily, a different approach from the ones above is required. Complex rehabilitations, in fact, require an approach which allows the completion of, on more than one tooth, all the provisional reconstructive phases, endodontic treatments, and periodontal surgical treatments necessary in one reconstructive phase, including conservative restorations and, if necessary, prosthetic restorations. The latter, as described in the literature, require more time (at least 2 to 3 months) for maturation of the tissues and stabilization of the gingival margins in the posterior areas.

To illustrate this, a case of a 32-year-old patient needing extended rehabilitation of the four quadrants as can be seen from the right and left bitewing radiographs (Figs 28 and 29) is presented. The rehabilitative phases of the right quadrants—in particular quadrants 1 and 4—will be described.

Regarding the first quadrant (Fig 30), once the endodontic emergency relating to the symptomatic tooth 15 had been resolved and followed by the initial preparatory stage, the first step was bone resection relating to teeth 15 to 17 in order to re-establish correct biologic width prior to removal of the old restorations, and careful removal of decayed tissues (Fig 31).

Once the sutures had been applied, the field was isolated with a dental dam and a pulpotomy (tooth 17) and provisional reconstructions of the two teeth in glass ionomer cement were carried out to create a seal and a correct interproximal contact





Figs 28 and 29 Initial bitewing radiograph right and left in patient with extensive caries.

Fig 30 Initial situation in quadrant 1 with serious decay at teeth 15, 16, and 17.

point. In the following appointment, endodontic treatment of tooth 17 was completed.

Three months after surgery, contemporarily with the rehabilitation of quadrant 4, the provisional restorations were removed and the cavities re-cleansed (Fig 32). A buildup was then begun with successive preparations for onlays with configurations and shapes that took into account the arrangement of the remaining healthy tissues (Fig 33).

The ideal appearance of the mature marginal tissues (Fig 34) and the ease with which it was possible to take a precision impression are evident. Once the models

Fig 31 Bone resection contextual with the removal of pre-existing restorations and cleansing of the carious lesions with pulp exposure at tooth 17.

Fig 32 Re-preparation of the cavity after 3 months and evaluation of residual dental thickness.

Fig 33 Buildup and definition of preparations for cusp coverage onlays.

Fig 34 Appearance of marginal periodontal tissues which have reached maturation.

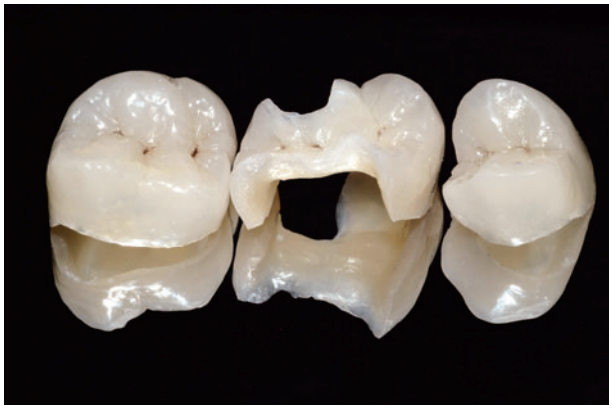


Fig 35 Composite overlays and onlay.

Fig 36 Quadrant 1 completed after adhesive cementation of restorations, finishing, and polishing.

had been created, onlays were then carried out using an indirect technique and were adhesively cemented in a single session 10 days later (Figs 35 and 36).

With the fourth quadrant (Fig 37) being simultaneously treated, it was possible to carry out the pre-endodontic reconstructions first, then the canal treatment of teeth 46 and 47, and the direct restorations of teeth 44 and 45. After that, bone resection was performed on the molars with a double-mixed vestibular flap and total lingual thickness (Fig 38).

At this point, teeth 46 and 47, which were rubber dam isolated with provisional restorative materials and carious residues removed, were evaluated separately for the preferred type of reconstruction. Tooth 46 required buildup and preparation for adhesive overlay, and 47 required a pre-prosthetic reconstruction in reinforced composite with fiber post and preparation for a total crown. This was due to the widespread loss of tissue and absence of enamel at the cervical level, which involved the box area and, in part, the axial walls (Figs 39 and 40).

The overlay for tooth 46 was built and cemented at the same time as the onlays of the first quadrant and with provisional composite on tooth 47 (Figs 41 and 42). The latter would, in fact, be permanently replaced with a ceramic crown coping in zirconium at the same time as the prosthetic restoration of teeth in the third quadrant—tooth 36 on implant support and tooth 35 on natural crown-radicular support (Figs 43 to 46).

The final, satisfactory result of the complete rehabilitation of the upper and lower arches can be clearly seen from the bitewing radiographs and clinical photos (Figs 47 to 51)

The classic approach described for this case is much more "elegant" than the combined surgical restorative approach with immediate impression or impression after 3 weeks. However, in the author's opinion, it should be reserved only for extended and complex cases since, for the reasons outlined here, preference should be given to immediate or early finalization of all cases.

Fig 37 Quadrant 4: inadequate pre-existing restorations with serious recurrent carious lesions.

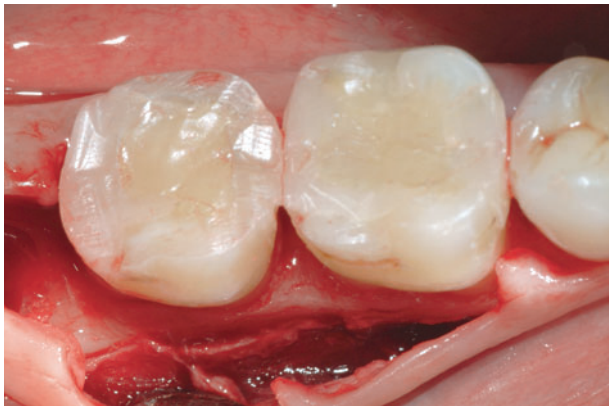


Fig 38 Surgical crown lengthening of teeth 46 and 47 following canal treatments.

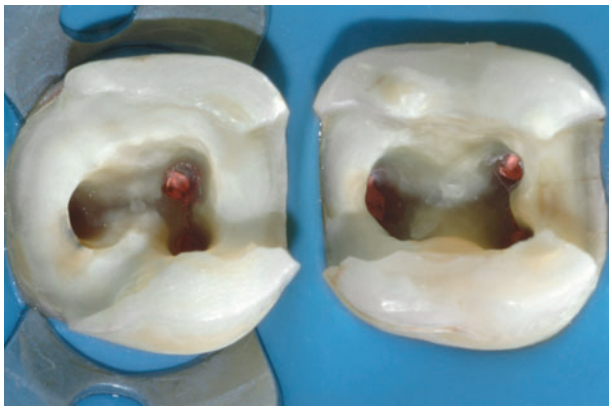


Fig 39 Residual dental tissue after cleansing and endodontic therapies.

Fig 40 Preparation for overlay on tooth 46 and total crown on tooth 47.

Fig 41 Contextual construction of manufactured parts in the two opposing quadrants.

Fig 42 Definite restoration in adhesively cemented composite of tooth 46 and provisional restoration in composite of tooth 47.

Fig 43 Final prosthetic preparation of tooth 47.

Fig 44 Zirconium ceramic crown permanently cemented

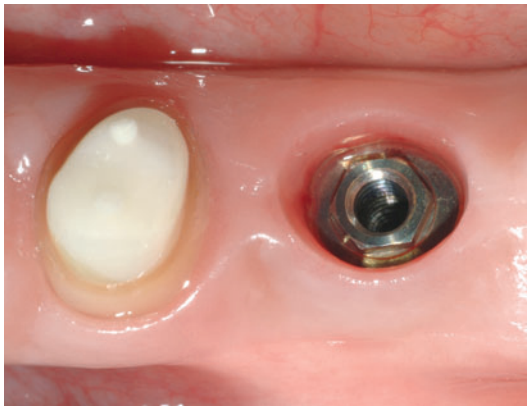
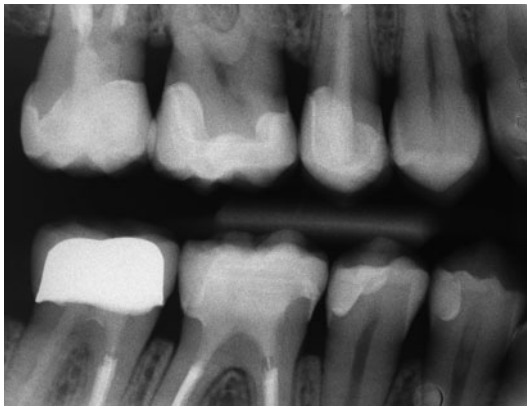
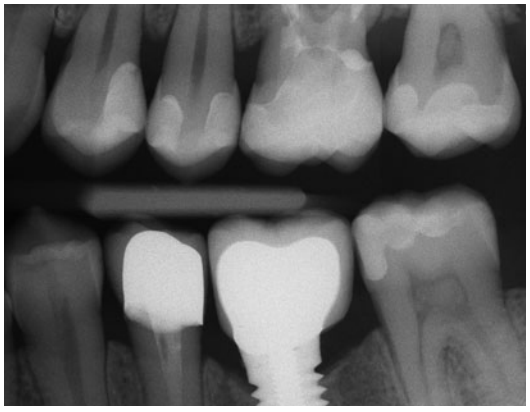


Fig 45 Prosthetic preparation of tooth 35 and implant fixture to replace tooth 36 that was previously extracted.

Fig 46 Zirconium ceramic crown cemented on natural abutment of tooth 35 and ceramo-metallic crown cemented on titanium abutment screwed to the implant support of tooth 36.





Figs 47 and 48 Final right and left bitewing radiographs.

Fig 49 Recall 1 year after completed rehabilitation of the maxillary arch.

Fig 50 Recall 1 year after completed rehabilitation of the mandibular arch.

Fig 51 Intercuspation of the two left quadrants after completed rehabilitation with good tissue response.

Conclusion

The purpose of the present article is to give the clinician a systematic, orderly, and predicable approach to dealing with conservative restorations of ample dimensions with cusp coverage and subgingival cervical margins. The proposed classification and the consequent differentiated therapeutic approach is based not only on clinical evidence, but also on a wide range of publications with bibliographical references to support the expressed theories and proposed operative sequences.

The article outlines the advantages, the limits, and the operative sequences relating to the procedure for coronal relocation of the margin and provides support for the use of flowable composites at the cervical level. The author particularly wishes to emphasize the combined surgical-restorative approach where surgery (clinical crown lengthening) is carried out contextually and in the same session with buildup, preparation for onlay, and impression taking, prior to adhesive cementing of the onlay in a second session after 1 week. This approach allows the case to be concluded in a very short time, eliminates problems connected with long intermediate phases with provisional restorations, and seals the cavity with a well-finished and polished definitive restoration with suitable emergence profiles, which allows for a rapid and favorable healing of the soft marginal tissues.

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