Esthetic direct restorations in endodontically treated anterior teeth

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Abstract

Composite resins are the most commonly used materials in restorative dentistry. When first introduced in dental practice, they began to change the esthetic approach to anterior teeth treatments. At first they simply represented a ‘white’ alternative to unesthetic materials. Today, the clinician can select different materials depending on the characteristics required, such as opalescence, fluorescence, translucency, transparency, viscosity, elasticity, and, obviously, shade. It is no longer a mere matter of selecting the right single syringe. The thicknesses of one or several materials may drastically change the final outcome. A three-dimensional way of planning restorations has overcome the old monochromatic bi-dimensional one.

Sound tooth preservation, affordable treatments, and reparability are only a few of the advantages of using composite resins.

Clinicians generally consider non-vital anterior teeth a big challenge from an esthetic point of view and they very often prefer to treat them with full or partial indirect ceramic restorations.

In the present article, through the analysis of several step-by-step clinical cases, the authors point out that direct restorations could lead to successful esthetic outcomes if correct techniques are applied in order to make up for the differences between vital and non-vital teeth.

(Eur J Esthet Dent 2013;8:44–67)
Introduction

Clinical procedures related to restoration of root canal treated teeth are often confusing for clinicians. This often occurs either because of obsolete knowledge or because of the huge diversity in published opinions. Adhesive dentistry has broadened the clinician’s possibilities and has made more conservative treatments possible.1

Bonding to enamel and dentin has led to an increased number of direct and indirect bonded restorations and to a reduction in porcelain fused to metal crowns. More conservative treatments avoid reaching an early end of a “tooth’s lifecycle”2 and are therefore preferable.

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Placing or not placing a post has become one of the most debated subjects, while it is well known that the most important element is to have as much dental structure as possible. In anterior teeth, as well as in posteriors, it is almost mandatory to have a “ferrule effect”.3,4,5

A proper ferrule reduces the incidence of fractures in non-vital teeth. The ferrule reinforces the tooth at its external surface, dissipating forces that concentrate at the narrowest circumference of the tooth.6

If the clinician has to deal with poor remaining dental structures, a periodontal crown lengthening or orthodontic extrusion can be performed in order to have a ferrule effect. Both solutions have to be evaluated very carefully in anterior teeth because of the esthetic consequences they may produce. Crown lengthening may lead to missing papillas, while orthodontic extrusion may produce a narrower emergence profile due to the root taper.7-10

Restoring non-vital anterior teeth means accurately planning and managing various aspects11,12 such as posts, color, form, preparation, and surface geography. Only a strict interconnection among these elements leads to a successful restoration.

Posts

Generally, when we have a sufficient tooth structure no post is required (Fig 1).13 Sometimes we have the opposite situation, where the tooth structure is very poor and more than one post is placed in order to support build-up material (Fig 2).

For many years, the cast gold post and core solution has been considered the “gold standard” in post-and-core restorations.14,15 Today we can count on alternatives to cast posts and cores. The use of prefabricated posts and custom-made build-ups with composite resin gives clinicians several advantages. It is time and cost saving, it simplifies the restorative procedure because all steps can be completed chairside, and a fair clinical success can be expected.16 Generally, a post is recommended in order to support build-up material, not to strengthen the tooth structure or to increase pull-out strength. In fact, it has been evaluated that the post length or design are of secondary importance for fracture resistance if a sufficient ferrule can be provided.6

Sometimes posts are placed if the clinician thinks that direct restorations are to be considered as a long-term provisional solution. In this way, we can have teeth ready to be prepared for prosthetic purposes whenever needed.
When a post is required, the clinician has to choose between the type of material and its shape:

- The material. While it is mandatory to use an esthetic post in the anterior teeth, especially when using direct restorations, which do not have a complete masquerading capacity, the clinician can choose between 3 kinds of posts: glass, quartz and zirconia. Scientific literature shows several issues related to zirconia posts, such as debonding, root fracture, etc.

- The authors of this article suggest the use of glass/quartz fibre posts, while the literature shows better results for their mechanical properties. Research is continuously evolving in its aim to develop new posts with different flexural properties.

- Post Shape. Companies provide us with posts with different tapers and with drills to create post space. Post space should be obtained by removing as little sound tooth as possible. Drills should only be used to remove endodontic filling. The post should be adapted to the canal shape; we should not modify the canal shape to make it “post compliant”. Therefore, it is better to have different shapes in order to select the most appropriate one and have uniform cement thickness.

Fiber posts are generally cut to size with a diamond disc after having delimited the length with a felt-tip pen. (Fig 3)

If the post needs to be placed in a region such as the palatal concavity, specific shape modification may be
**Fig 4** Posts can be shaped for anatomic purposes.

**Fig 5** (a and b) When no post is required, the endodontic filling is removed at least 2 mm below bone level. (c) A flowable composite resin is placed right above the endodontic filling. A high opacity, high value and fluorescent flowable composite resin is preferred, as it may balance dentin fluorescence loss and can be easily detected in case new treatments or future post placements are needed. (d and e) Layering of dentin and enamel.

**Fig 6** (a and b) A post space is created, removing as little sound tissue as possible. Drills are only used for removing endodontic filling. (c) Post is shortened so that it may fit (though passively) in the best way in the canal and it is also shaped so that it may be covered with a uniform restorative material layer. (d) Post is cemented with auto or dual composite cement. (e) In order to avoid bubbles and to fill undercuts, a small amount of flowable composite resin (violet in the diagram) is placed around post and post cement. Layering is then completed with dentin and enamel composite.
performed through the use of abrasive discs (Figs 4a and 4b).

Color and form

The color of a tooth is determined by the dentinal body. Enamel works as a modifier of the dentin color, and its thickness (changing over time) is decisive for the final color of the tooth (Fig 7).24

When we choose a color for our restoration, we choose a single base hue dentin with different chromatic shades, and an enamel able to modify the color.25 While various thicknesses from the cervical to the incisor area are to be created, clinical experience suggests using a minimum number of dentin colors varying enamel thickness to modify the base color.26

Therefore, it is mandatory to plan the space dedicated to each material. Small excesses or under-applications could determine esthetic failure and the need to repeat the restoration.27-31
So, while the thickness of every mass is pre-determined, the shape and the form of the surface reconstruction has to be considered. In order to do this, we need an efficient and stable guide for layering our masses, and the rigid silicone matrix provides this. This useful device can be obtained in three different ways:

- From the old restoration before removing it.
- From a pre-restoration (it is simply a matter of applying, modeling and polymerizing composite resin directly on the tooth without the use of the adhesive system).
- From a wax-up (Figs 8a and 8b).

When we need to restore the interproximal surfaces, preformed sectional guides with multiple convexities are often very useful. They easily provide a natural emergence profile and optimize the position of the interproximal contact point.

With the silicone matrix we have defined the palatal surface; with the preformed sectional guides we have defined the interproximal ones. Now we need something to help us restore the thickness.

What is the thickness of the dentin layer? And, much more importantly, what is the thickness of the enamel? With nearly all enamel materials, the thicker they are the more they tend to increase the “greyish effect,” hence dulling the underlying color of the dentin. What we need is more silicone indexes cut along the sagittal plane (Fig 9). In this way (as we do in prosthetic dentistry), the clinician can control the thickness of the two materials. We can also count on new instruments designed by the “Style Italiano” study club, that help measure the thickness of the enamel layer. (Fig 10).

Because of its different refractive index, we should leave space for composite enamel no larger than a half of a natural enamel thickness. Today we also have highly refractive composite enamels that have a refractive index very close to that of natural enamel.32-37

Tooth preparation

The preparation of the tooth begins by removing old restorations and caries. After that, unsupported enamel is removed and a margin is defined. This is characterized by a small chamfer in the vestibular portion (to make the transition from composite to natural enamel invisible) and in flat margins (90 degrees) in the interproximal and in the palatal portion.

Great care has to be taken in finishing the preparation margins, using silicone points mounted on a blue ring counterangled hand piece, at a low speed, to carefully smoothen the preparation and remove unsupported enamel prisms, which would break off during light curing contraction, leading to discoloring and infiltration of the restoration. This operation has to be carried out under a constant cooling spray.25

The surface

Every single step in direct restorations is important. Often clinicians devote too little time to taking care of the restoration surface. This happens because often the clinician only regards the “color matching” issue. This is a common er-
ror, while surface management is in fact just as important as the form, being a part of it. Technicians spend a long time polishing indirect ceramic restorations before sending them to dental offices. In direct restorations we have to do this ourselves. Macro and micro-geography have to be reproduced carefully. Young teeth have a very well pronounced macro and micro-geography, while aged teeth have smoother surfaces. Sometimes we can play with the micro-geography in order to obtain more light-reflecting areas. This can give the illusion of a tooth with a higher value. While non-vital teeth have generally a lower value, this can be a technique used to solve the problem.

**Clinical cases**

In the following clinical cases, "step-by-step" procedures related to various aspects of direct restoration of non-vital teeth will be described.

**Case 1**

Initial photos (Figs 11a and 11b) show inappropriate composite restorations for teeth 12, 11, 21, and 22. Tooth 21 was also discromic.

The radiograph (Fig 12) shows radiopaque material in the periapical region of tooth 21 with no root treatment. Areas of demineralization can be seen around nearly all the restorations.

Tooth 21 has been root treated and a new apicoectomy was performed.

A cervical seal with a light colored flowable resin (in order to be easily found when the post space has to be created) was made in order to bleach the tooth (Figs 13a and 13b). The coronal height of the seal should protect the dentinal tubules and conform to the external epithelial attachment. Bleaching was then performed internally and externally.

An impression was made in order to make a wax-up.

Silicone indexes were made on the wax-up (Fig 14) and a personalized color...
chart was also compiled, subsequent to careful analysis of the teeth under a light source of 5500 K.

After at least 21 days after bleaching, adhesive and restorative procedures can be performed. After carefully isolating the operative field with the rubber dam, and checking the rigid silicone matrix guide to fit perfectly by trimming it with number 15 scalpel blade where necessary, the old and provisional fillings were removed using a medium
grain cylindrical diamond bur. Preparation was performed with the above mentioned criteria defining a chamfer on the vestibular finishing line. (Figs 15a and 15b).

A post has been placed in order to sustain restorative material and because it may turn out to be useful for a future crown coverage of the tooth. The post was cut to size and shaped in order to reflect palatal concavity and to be covered completely by the composite resin. The palatal wall of the tooth was restored by placing composite resin directly on the silicone guide after having defined on it the palatal region with an explorer (Figs 16a–16c).

A sectional matrix with multiple convexities was used for restoring the interproximal anatomy (Fig 17). Furthermore, it was also used to avoid accidental contamination of adjacent teeth during adhesive procedures. Once the cavity’s solid was limited by interproximal well-defined margins and incisal angles, it was possible to focus on building up the dentinal body (Fig 18).

The dentinal body was built leaving enough space to add the specific opalescence taken from the color scheme compiled in the preliminary investigative phase. Management of the internal composite thickness was controlled using another laboratory-produced rigid silicone matrix sectioned in the sagittal plane, as seen previously (Fig 9). This made it possible to control the quantity
Fig 16  (a) Post selection. (b) Post is shaped in accordance to palatal wall. (c) Palatal wall is layered.

Fig 17  Mescal and incisal portions are restored.

Fig 18  Dentin is layered on 2.1

Fig 19  1.1 and 2.1 before polishing.
and distribution of the composite dentin in section, in order to leave just the right space for the enamel and not to lower the value of the restorations. Layering finished with a very thin layer of composite enamel no thicker than 0.3 to 0.4 mm (Fig 19).

The same procedure was followed to layer composite resin on tooth 11. A final 60-second curing was performed under glycerine, which eliminates oxygen access to the surface. This procedure will provide the composite resin’s complete polymerization, improving surface resistance and giving better polishing performances.

Case 2

The patient (Fig 22) complained of discoloration around fillings and restoration translucency. Because the color of the two central incisors did not differ much from the contiguous teeth and to avoid the risk of a bleaching color relapse, it was decided not to perform bleaching. Root treatments for teeth 11 and 21 were unsatisfactory (Fig 23) and had to be repeated.

Removing old restorations was done carefully, because every single portion of sound tooth was crucial for the prospective restoration. Often we have big
bevels and fortunately restorative material is sometimes thicker and overlaps sound enamel. Unfortunately this was not the case here (Fig 24).

First of all a high-contrast fluorescent white flowable composite resin was used as a cervical seal so it could be easily found in case of new treatment or post insertion needs (Fig 25). An opaque, high value, fluorescent composite was used to build the dentin body, starting from the cervical seal.

Both of the interproximal walls were raised in one single step, using sectional transparent matrices with multiple convexities (KerrHawe) in order to keep proportions between the two central incisors and to control the mid-line. It is also a time-saving procedure and can be quickly removed and made once again if we notice differences when comparing dental and facial mid-lines (Fig 26). Due to the poor thickness of interproximal walls, putting a little amount of flowable composite resin at the base of the walls would help their consistency.

The palatal wall and the incisal portion were built as a second step, stratifying composite resin on the silicone index. Then the two “frames” were filled with dentin and then with a thin enamel layer (Fig 27).

While dehydration occurs using the dental dam, it is very important to have a color chart compiled on hydrated teeth. A tip for managing low teeth value is a marked micro-geography which raises the number of reflecting areas, giving the illusion of a higher value. Finally, a shiny smooth surface will give the restoration a more natural aspect and it will blend more effectively (Fig 29).
Fig 24  Teeth preparation.

Fig 25  Cervical seal is performed with white flowable composite resin.

Fig 26  Interproximal walls.

Fig 27  Incisal and palatal walls.

Fig 28  Restorations before polishing.
Case 3

Teeth 13, 12 and 11 had old restorations that needed to be substituted because of secondary caries and discoloration. Tooth 12 also underwent a root canal treatment (Fig 31).

All old restorations, secondary caries and temporary fillings were removed. Particular attention was given to saving as much sound enamel possible. In this particular case, tooth 12 had a precious buccal enamel wall, which was crucial to a predictable esthetic outcome (Fig 32).

The post space was then created, removing root canal filling and shaping it. Largo burs and postspecific burs were used for this purpose. To obtain a good post space debridement, sandblasting with aluminium oxide or air polishing with glycine-based powder was performed. After having selected the correct post, the length can be adjusted, cutting the excess. The post should be completely covered by the restorative material, so this has to be kept in mind when adjusting post length and shape.

A 3-step etch and rinse was then used to perform the adhesive procedure. A self-cure activator may be added to the adhesive when used in the root canal. This is done because light cannot reach the deepest portion of the root canal. The post was placed using a small quantity of post cement only for the canal portion. After curing it, the restoration was performed using composite resin. A flowable composite resin is use-
Fig 31  Initial situation.

Fig 32  Tooth preparation.

Fig 33  Step-by-step post placement procedures.
ful to fill in hard-to-reach portions, especially around the deepest portion of the post. In this way, it is possible to avoid bubbles in the restoration (Figs 33a and 33b).

Case 4

This patient complained about the color of her teeth (Fig 35), in particular, tooth 22. The radiograph showed the need for

Fig 34  (a and b) The clinical view of the final result.

Fig 35  Initial situation.

Fig 36  Initial radiograph.
endodontic and conservative treatments and retreatments (Fig 36). After having endodontically treated teeth 12 and 22 and after having set a reliable cervical seal, an external and internal bleaching was performed on those teeth (Fig 37).

In this case, a bleaching agent (White-ness HP Maxx, FGM) was used, which changes color to green when its efficacy is over (Fig 38). This could be useful to optimize chair time for more than one application. Vital teeth were treated with the same bleaching agent. A liquid dam was used to protect soft tissues (Fig 39).

A personalized colour chart was prepared after the bleaching treatment and before applying the rubber dam. (Fig 42)

Three weeks after the end of bleaching, the rubber dam was applied and teeth were restored in a single chair appointment (Figs 43–50).
**Fig 41** Wax-up and silicon matrix.

**Fig 42** A personalized color chart was prepared after the bleaching treatment and before applying the rubber dam.

**Fig 43** Teeth preparation.

**Fig 44** Frontal view of teeth preparation.

**Fig 45** Interproximal walls are built-up with the help of sectional matrixes.
Fig 46  Composite layering steps on tooth 21.

Fig 47  (a and b) Sectional matrixes make our treatment quicker and predictable.

Fig 48  Restorations finished and polished.
As we have seen, a non-vital tooth has little coronal dentin. This causes the tooth to have less fluorescence and to appear dull. For this reason we have to minimize this inconvenience by applying one or more of the following procedures:

- Using (when the use of a post is chosen) posts with high levels of fluorescence to make up for the lack of dentin. These posts integrate with the material in the reconstruction, illuminating the tooth from within, making it appear less dull.

- Using fluorescent and opaque dentin. Composite dentin has to cover either the blackness of the oral cavity or the tooth substrate, in order to raise the tooth value and avoid the “grey” aspect of a restoration.

- Emphasize micro and macro-geography in order to raise the tooth's value “perception”.

**Fig 49** A close-up of the final result.

**Fig 50** Final radiograph.
Conclusions

The procedures exposed in this article can be the key to the long-term success of a restoration from both a clinical and esthetic point of view.

The combined application of silicone indexes and sectional matrices allows the clinician to manage directly, in a single step, complex direct restoration cases, thus optimizing both operative time and the final result.

It is crucial to understand that a successful restoration begins with a correct initial treatment plan, which is often based on impressions and wax-up. After this, the knowledge of material composition, optical properties and overall characteristics is mandatory in order to give a natural aspect and a predictable performance to our restorations. Clinicians often look for a miracle material, but the final result is fundamentally linked to the clinician's manual skills and knowledge and, what is more, skills in choosing the correct techniques that simplify everyday work.

All steps in direct restorations are mandatory. The procedures, and especially the time to finish and polish direct restorations, are to be respected. Too often, composite resins are considered unreliable for esthetic purposes, but rarely are they managed as they should. Recent indirect solutions are in fact based on a\textsuperscript{41,42,43} composite prefabricated veneer system. This points out that this material can be rightfully used for esthetic purposes and gives the clinician the possibility to manage every step of restoration.

With composite resin materials, we can carry out esthetic restorations that are minimally invasive, affordable for patients, and long-lasting.

Repairing fractures or defects in the material is relatively easy and cheap, and it is not necessary to carry out the whole restoration again.

The clinician has to deal with the loss of natural fluorescence of non-vital teeth because a great amount of coronal dentin, which is the most responsible for fluorescence, has been removed to perform the endodontic treatment. Generally, a post is only recommended only when a big portion of the tooth is missing to sustain the material and in consideration of any future treatment.

Direct restorations should be considered as an effective choice when restoring root-treated teeth, while indirect solutions like veneers or crowns inevitably lead to further tooth structure loss.

Acknowledgements

The endodontic treatments shown in the radiographs of this paper were performed by Dr Federico Menghetti and Dr Roberto Kaitasas. The clinical procedures detailed in this paper were performed by Style Italiano club members (www.styleitaliano.org).
References


