The Gray Zone Around Dental Implants: Keys to Esthetic Success

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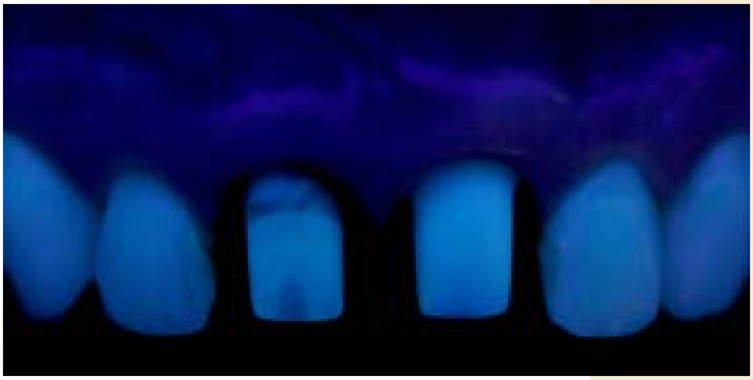

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Single-implant restorations in the anterior maxilla have become a routine treatment option. While customized tooth-colored prosthetic components show greatly improved clinical outcomes, esthetic success relies not only on the restorative result, but also on the condition of the soft tissues. A common esthetic shortcoming is the grayish appearance of the peri-implant soft tissues, which are difficult to manipulate around dental implants. The parameters and clinical guidelines that should be used to influence esthetic success and avoid the gray zone around implant restorations can be categorized into five key factors: *(1)* optimal three-dimensional implant placement for functional and esthetic long-term implant success; *(2)* maximized soft tissue thickness to conceal the implant-restorative interface; *(3)* proper abutment selection to improve biocompatibility, tissue stability, color, translucency, and fluorescence; *(4)* careful crown restoration to imitate the natural teeth; and *(5)* awareness of the lip line, which may greatly influence the final outcome. Mimicking the inherent optical properties, especially fluorescence, of natural teeth with implant components and crown materials is fundamental for ideal restorative and soft tissue esthetics. *(Am J Esthet Dent 2011;1:xxx–xxx.)*

The esthetic success of a dental restoration is judged by its integration with the surrounding dentition in respect to position, angulation, dimensions, proportions, shape, surface morphology, and shade.[1–3] Other crucial esthetic parameters that are often overlooked include the morphology, texture, and ultimately the color of the surrounding gingiva.[3,4] The soft tissue is the natural frame of the teeth and any dental restoration, and is, therefore, a fundamental parameter for esthetic success.[1,3,5] This aspect is often neglected because successful soft tissue outcomes—including handling, manipulation, and healing—are very demanding, time intensive, and unpredictable.[5] Magne et al[6] described a prevalence of grayish soft tissue discolorations around tooth-supported full-coverage porcelain-fused-to-metal and even all-ceramic restorations. Interestingly, other perioral facial parameters such as position of the upper lip and height of the smile line[7–9] also seem to influence the degree of gingiva discoloration. The authors note that "this problem is particularly evident in the presence of the upper lip, which can generate an "umbrella effect" characterized by gray marginal gingivae and dark interdental papillae."[6]

This umbrella effect is magnified with dental implant restorations in the anterior maxilla because the supporting hard and soft tissues are often compromised even before restorative treatment and are influenced by the color and design of the implant, its prosthetic components, and the definitive restoration.[10–17] Therefore, ideal periodontal and restorative esthetic success with maxillary anterior implant-supported restorations presents a great challenge for the entire dental team and depends on a variety of parameters.[10–14]

The parameters and clinical guidelines that should be used to influence esthetic success and avoid the gray zone around implant restorations can be categorized into five key factors: *(1)* optimal three-dimensional (3D) implant placement for functional and esthetic long-term implant success; *(2)* maximized soft tissue thickness to conceal the implant-prosthetic component interface; *(3)* proper abutment selection to improve biocompatibility, tissue stability, and color to provide a perfect blend with surrounding tissues and teeth; *(4)* careful crown restoration to imitate the natural teeth; and *(5)* awareness of the lip line, which may greatly influence the final outcome.

3D IMPLANT PLACEMENT

The fundamental factor for long-term functional and esthetic success as well as soft tissue color and stability is optimal 3D implant placement.[18] A simple but essential guideline is to position the implant as close as possible to where the natural tooth was or ideally would be.[10] If a line is drawn at the center of the implant along its long axis and extending through the tooth restoration, it should run through the center of the incisal edge of the prospective tooth (Fig 1). The greater the 3D mismatch between the crown and implant body, the poorer and less stable the final outcome will be. The incisal edge is also the target for the angulation of the implant. An implant that is angulated too far to the buccal aspect will result in greater tissue recession under functional load. Conversely, a palatally placed implant leads to a more extreme emergence profile, resulting in increased bone resorption and thinning of the tissues. Both situations will lead to an intensified grayish appearance of the soft tissues at the gingival margin.

The third dimension is determined by the depth of the implant in respect to the marginal bone and soft tissue. An implant placed at the proper depth allows for the development of an ideal emergence profile and a soft tissue collar void of a gray zone. It is impossible to create a proper emergence profile when the implant is placed too shallow, while an implant placed too deep is difficult to manage clinically and increases the possibility of peri-implant infection, inflammation, and bone loss.

A surgical guide fabricated from the diagnostic wax-up/setup is an indispensible tool to ensure proper 3D implant placement. The anticipated incisal edge position of the final tooth restoration determines the position, angulation, and depth of the implant in all three dimensions, which directly influence the position, height, and thickness of the surrounding hard and soft tissues.[10,12]

Fig 1 Maxillary anterior implants should be positioned and angulated so that a virtual line through the center of the implant along its long axis would run through the center of the incisal edge of the prospective crown.

SOFT TISSUE THICKNESS

Even in cases where ideal implant placement was achieved, the esthetic outcome may become compromised over time due to resorption of the marginal bone and soft tissues.[5,19]

Case 1

Figs 2a and 2b A modified metal abutment was used after immediate implant placement at the maxillary right central incisor site without bone or soft tissue augmentation.

Fig 3 Postoperative situation showing the implant-supported crown.

Fig 4 Follow-up view after several years reveals a grayish appearance of the soft tissues.

Fig 5 Follow-up view after 11 years showing soft tissue discoloration due to the metal abutment.

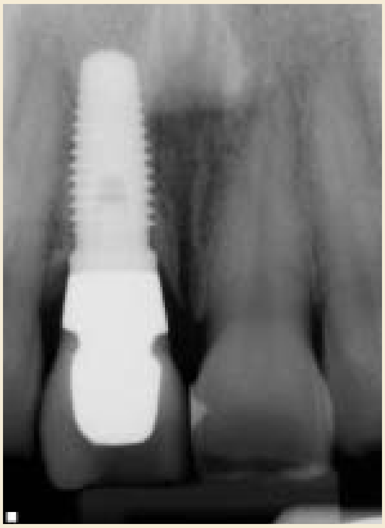


Fig 6 Periapical radiograph after 11 years reveals loss of buccal bone.

Case 1 (Figs 2 to 6) illustrates a situation where a single implant was placed immediately after extraction of the maxillary right central incisor without any hard or soft tissue augmentation. A modified metal abutment was fabricated, and the definitive restoration was inserted (Figs 2 and 3). A follow-up photograph taken several years postoperatively reveals a grayish appearance of the soft tissue surrounding the implant restoration (Fig 4). This discoloration becomes increasingly evident 11 years after completion as a result of the resorption of the buccal bone and surrounding soft tissues, revealing the unfavorable gray color of the metal implant abutment (Figs 5 and 6).

To avoid this result, it is advisable to maximize tissue thickness in every case and for both delayed and immediate implant placement.[19–22] In fact, the mucosal characteristics of the peri-implant tissues necessitate connective tissue grafting for long-term esthetic success.[21] With clear surgical objectives, a modern approach should always include the most conservative procedure that satisfies the esthetic and functional requirements. For example, if a bone graft is unnecessary, stage-one surgery should always be performed with a minimal flap incision, such as a split-thickness flap or even no flap, to avoid unnecessary exposure of the underlying bone. Several authors have indicated that flapless surgical implant placement using computer-assisted surgical guides minimizes bone resorption, preserves soft tissue architecture, and improves the healing process.[23] While some of these results still need to be verified in long-term clinical trials, the positive effects of flapless implant placement on patient comfort due to the minimally invasive nature of the procedure are clearly evident.[23] The key components of this surgical process are maintenance of the interproximal bone, minimal bone exposure only on the implant site, precise coronal graft suturing central to the implant axis, and tension-free flap closure and adaptation.

The design of the healing abutment, which can be placed during or after connective tissue grafting, is another critical issue. Connective tissue grafts (CTGs) are placed around implants to enhance gingival margin stability and create a more fibrous and less mobile tissue complex.[19–22] In dentistry today, the clinician's search for soft tissue abundance in the early stages of implant treatment means creating a large amount of soft tissue during or soon after implant placement and manipulating these tissues during the prosthetic phase. This is a shift from traditional approaches in which multiple subsequent soft tissue grafts were performed until the desired thickness was achieved. Multiple surgical interventions, however, are less predictable because the scarring and compromised blood supply make every subsequent grafting attempt more challenging. For ideal prosthetic soft tissue manipulation, the healing abutment should be significantly narrower than the tooth to be replaced. At first, the tissue will not have the same scalloped architecture as found around natural teeth. However, when the provisional restoration is placed, its subgingival contour and shape will determine the position and scallop of the soft tissue margin.[10,13] It also seems advantageous to connect the definitive abutment as early as possible and not to remove it after that time.

Thicker peri-implant soft tissue masks the implant-abutment-restoration interface and provides a better color match between the soft tissues around the implant and those around the neighboring teeth.[15–17] Some basic guidelines for tissue thickness and abutment selection are as follows:

- A soft tissue thickness greater than 3 mm allows for the use of titanium or zirconia abutments without negative esthetic implications.
- A thin soft tissue of less than 2 to 3 mm requires either a CTG or zirconia abutment.
- A dentin-colored abutment is always preferred.

Case 2

Fig 7 Case 2: Thin peri-implant soft tissue of only 1 mm was evident on the buccal aspect.

Fig 8 A custom-colored zirconia abutment (Procera, Nobel Biocare) was fabricated to optimize the esthetic outcome.

Fig 9 Colored zirconia abutment and alumina crown (Procera Crown Alumina, Nobel Biocare).

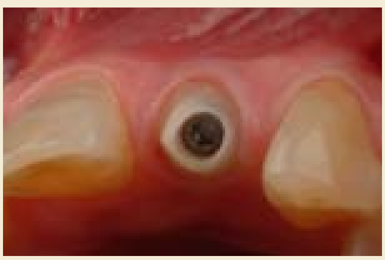


Fig 10 Intraoral occlusal view showing the soft tissue support.

Fig 11 Postoperative buccal view. The tooth-colored abutment and all-ceramic crown blend favorably with the adjacent teeth and surrounding soft tissue despite the compromised soft tissue thickness.

Fig 12 Postoperative periapical radiograph.

Fig 13 *(Left)* Occlusal view of the definitive implant-supported restoration.

In Case 2 (Figs 7 to 13), a colored instead of a white zirconia abutment was placed due to the presence of less than 1 mm of labial soft tissue. This approach, along with the adequate soft tissue support and contour, provided a satisfying outcome.

ABUTMENT SELECTION

In an evaluation of the soft tissue around single-tooth implant crowns, Fürhauser et al[24] showed that the color of the peri-implant soft tissue matched that of the reference tooth in no more than one-third of cases. Another study found that all-ceramic implant abutment and crown materials provide a better soft tissue color match with neighboring teeth than do conventional metal-alloy components.[16] Zirconia has been shown to be the preferred implant abutment material due to its high strength[13,25,26] and excellent biocompatibility.[27–29] The shortcomings of zirconia include its higher cost and unfavorable optical properties in regard to color and fluorescence.[30]

Case 3

Fig 14 Preoperative periapical radiograph of the missing maxillary left central incisor.

Fig 15 Preoperative intraoral situation.

Fig 16 Lateral tomogram showing the extent of the ridge defect.

Fig 17 Intraoral view of the edentulous ridge topography.

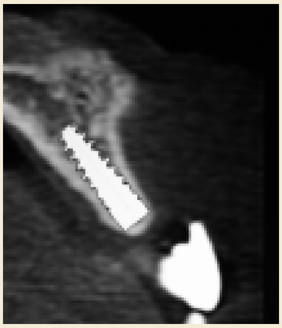


Fig 18 Virtual implant placement for guided surgery.

Case 3 (Figs 14 to 55) includes all previously described factors and treatment parameters. The missing maxillary left central incisor was replaced with a dental implant (Figs 14 to 18). Ideal 3D implant placement was planned on the computer and transferred via guided surgery. During stage-one surgery, the implant (3.5 × 13 mm, NobelActive, Nobel Biocare) was inserted, and a CTG harvested from the maxillary tuberosity was placed to increase tissue thickness (Figs 19 to 23). Figure 24 shows the augmented edentulous ridge 6 months postoperatively. Next, a zirconia abutment was connected to the implant, and a provisional restoration was fabricated, relined in the oral cavity, and cemented (Figs 25 to 29). The different lighting conditions (natural and ultraviolet [UV] light) shown in Figs 30 to 33 reveal the optical shortcomings of these materials, especially the lack of natural fluorescence. Figure 34 shows the detailed optical characteristics of natural enamel and dentin under different light sources.

Case 3 *Continued*

Fig 19 Implant placement (3.5 × 13 mm, NobelActive, Nobel Biocare).

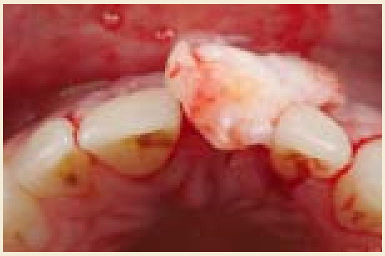


Fig 20 A subepithelial CTG was harvested from the maxillary tuberosity to augment the deficient ridge.

Fig 21 After placement of the CTG, the flaps were adapted without tension and sutured with thin suture material to limit trauma.

Fig 22 Labial view of the adapted flap after suturing.

Fig 23 Intraoral situation 1 week postoperatively.

Fig 24 Postoperative situation after 6 months reveals improved ridge morphology.

Fig 25 Definitive zirconia abutment and provisional restoration.

Fig 26 Insertion of the colored zirconia abutment.

Fig 27 Try-in of the provisional crown.

Fig 28 Precision of fit was verified extraorally.

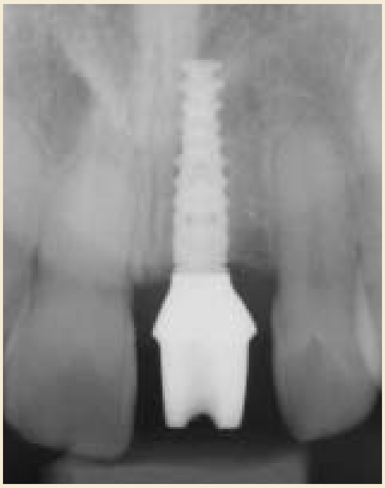


Fig 29 *(Left)* Periapical radiograph used to verify fit.

Case 3 *Continued*

Fig 30 *(Left)* Optical properties of the provisional crown under natural light.

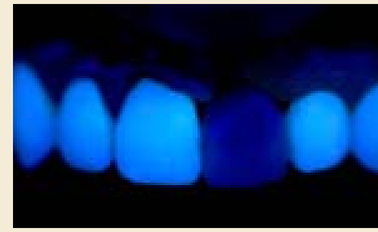


Fig 31 *(Right)* Optical properties of the provisional crown under UV light. Note the lack of fluorescence.

Fig 32 *(Left)* Optical properties of the zirconia abutment under natural light.

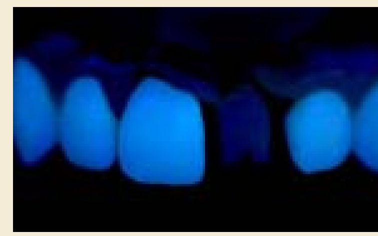


Fig 33 *(Right)* Optical properties of the zirconia abutment under UV light reveals a lack of fluorescence.

Fig 34 Color characteristics of natural enamel and dentin: *(a)* The three basic color zones; *(b)* areas of brightness/value; *(c)* enamel characteristics under a polarizing filter; *(d)* color characteristics of dentin; *(e)* degrees of dentin fluorescence under UV light.

Fluorescence is a crucial property for natural esthetics.[30–32] Colorants and fluorescent modifiers that can be applied to zirconia abutments even after milling and finishing have recently been developed.[30] The abutment or framework is dipped into a fluorescent coloring liquid before sintering to infiltrate the zirconia (Colour Liquid Fluoreszenz, Zirkonzahn). The abutment is blow dried after the dipping process to remove the excess and then placed under a drying lamp to prevent damage to the heating elements of the sinter furnace.

In addition to the regular zirconia, a more translucent zirconia (Prettau Zirconia "Translucent," Zirkonzahn) as along with 16 coloring liquids (Zirkonzahn) are available. Figures 35 to 37 illustrate the infiltration process and its effect on the optical appearance under different light sources. Three different abutments were fabricated: translucent zirconia with and without fluorescence and conventional zirconia with fluorescence. Figures 38 to 40 show the patient's favorable soft tissue thickness and the clinical try-in of the three different abutments under regular and UV

Case 3 *Continued*

Fig 35 Three different abutments were fabricated with conventional zirconia, a more translucent zirconia (Prettau Zirconia "Translucent," Zirkonzahn), and fluorescent colorants (Colour Liquid Fluoreszenz, Zirkonzahn): colored translucent zirconia with fluorescence (transl + fluoresc) and without fluorescence (translucent), and conventional zirconia with fluorescence (Zr + fluoresc). Natural light reveals the chroma characteristics.

Fig 36 Fabrication of a fluorescent abutment: (a) Provisional composite abutment; (b) duplicated zirconia abutment before the sinter process; (c) dipping of the zirconia abutment into fluorescent colorants before sintering; (d) final abutment after sintering.

Fig 37 The three different abutments under UV light. Conventional colored zirconia and fluorescing liquid (Zr + fluoresc) reveal the most favorable effect.

light. Interestingly, the translucent abutment provided the best match in natural light, but the worst under UV light. The most favorable fluorescent effect was achieved with colored conventional zirconia and fluorescing liquid.

In summary, the selection of zirconia implant abutments should be based on the following factors:

- 3D implant position: The screw-access opening in the abutment

Case 3 *Continued*

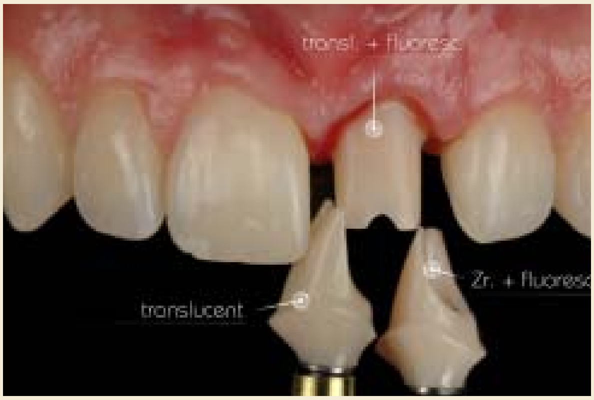
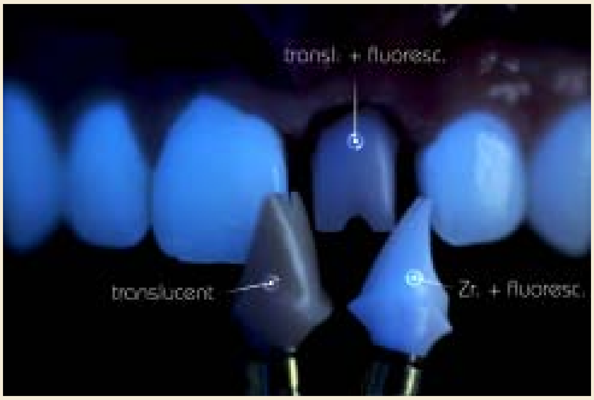


Fig 38 Intraoral try-in of the three abutments under natural light.

Fig 39 Ideal soft tissue thickness (> 3 mm).

Fig 40 Intraoral try-in of the three abutments under UV light.



should not compromise mechanical strength, and the circumferential thickness should be at least 0.8 mm.

- Soft tissue thickness: A minimum of 3 mm is ideal.
- Interocclusal space: Sufficient abutment height is required for ideal strength and resistance.
- Implant abutment color: The order of priority should be fluorescence/value, translucency, and shade (chroma and hue).
- Color of the intended crown restoration (alumina versus zirconia).

For optimal stability and fit of the coping, the preparation margin of the implant abutment is generally a circumferential chamfer or rounded shoulder. On the labial aspect, the margin is typically placed deeper than on the palatal aspect, but should not extend more than 1 mm subgingivally to avoid difficulties during cement removal. The abutment should support about 90% of the total surrounding soft tissue contour, with the crown supporting no more than 10%.[30]

The provisional restoration generally remains in place for 4 to 6 weeks until the position of the tissue is stable. A final impression of the abutment should then be made to transfer this information to the laboratory for fabrication of the definitive restoration.

Case 3 *Continued*

Fig 41 The influence of fluorescent stains on the value and chroma of alumina and zirconia copings under natural light: (a and c) without fluorescence; (b and d) with fluorescence.

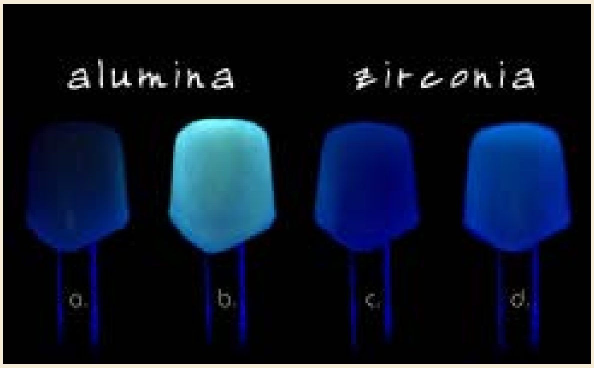


Fig 42 Fluorescent properties of alumina and zirconia copings under UV light: (a and c) without fluorescence; (b and d) with fluorescence.

CROWN RESTORATION

The definitive crown material is selected based on its core structure to enhance the optical characteristics of the intended restoration. The coping is chosen by its ability either to mask underlying structures or to complement the underlying abutment color. Zirconia is increasingly used as a coping material due to its versatility in respect to strength, thickness, color, and translucency, but especially due to its inherent brightness and options for fluorescence through infiltration.[13–17,30] It seems only logical that when a fluorescent abutment is used, the material selected for the definitive crown should also offer a certain degree of fluorescence to match the adjacent natural dentition.[30–32] It is important to evaluate the optical properties of the coping in relation to the remaining natural dentition under different light sources. UV light reveals the dramatic effects of fluorescence, which provides the vitality and brightness exhibited by natural teeth.

Fluorescence is an inherent property of natural teeth[31,32] but is rarely found in "esthetic" dental materials.[33–40] In natural teeth, the root and coronal dentin show the highest degree of fluorescence, especially in the gingival third, while enamel has low fluorescent properties.[30–32] Ceramic coping materials such as alumina[37] and zirconia[39] do not provide natural fluorescence and, therefore, are treated with fluorescent modifiers and/or veneered with fluorescent dentin stains, liners, and shoulder porcelains.[30,37,39] As in natural teeth, the fluorescent effect is most prominent in the gingival third of the restoration. Therefore, natural fluorescence does not only influence the optical effects of the restoration itself, but also greatly influences the color and appearance of the surrounding soft tissues.[30]

Figures 41 to 55 show the selection of the definitive coping material and the final outcome of Case 3. Figures 41 and 42 reveal the influence of fluorescent stains on the value and chroma of alumina and zirconia copings under natu-

Case 3 *Continued*

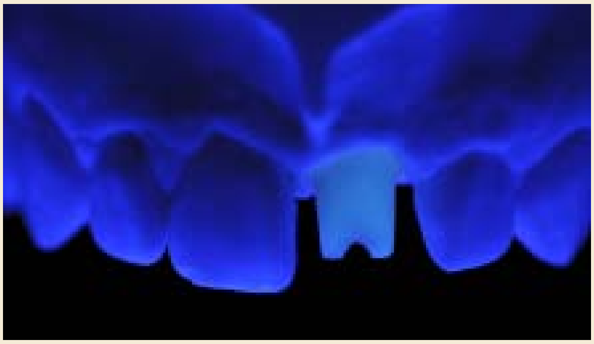


Fig 43 Definitive fluorescent abutment on the stone cast demonstrating ideal fluorescence under UV light.

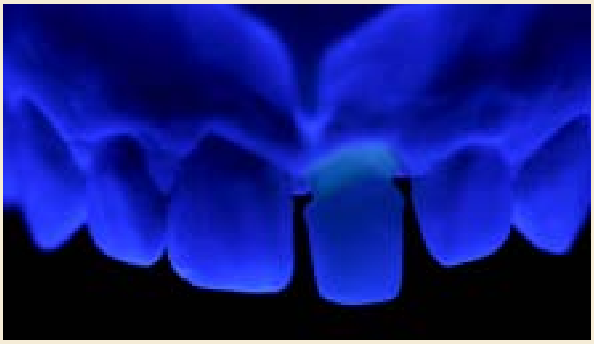


Fig 44 Nonfluorescent coping on the cast under UV light.

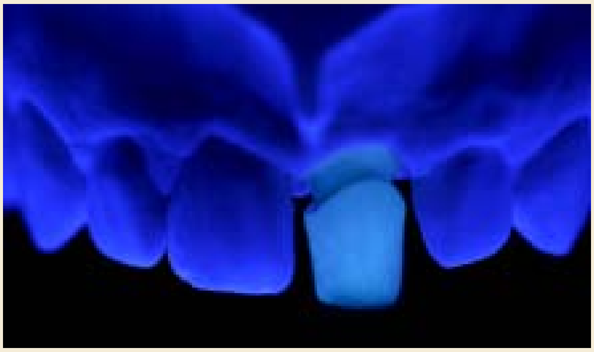


Fig 45 Fluorescent coping on the cast under UV light.

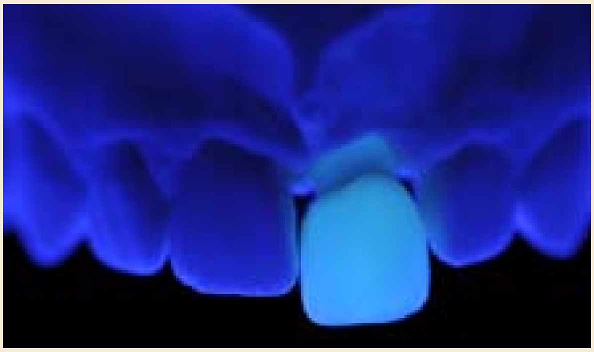


Fig 46 Definitive crown showing fluorescent properties under UV light.

ral and UV light. The impact of using a fluorescent (Fig 43) versus a nonfluorescent coping (Fig 44) is quite obvious on the stone cast (Figs 45 and 46) and even more so in the oral cavity (Figs 47 to 55). The definitive implant-supported crown shows optical and fluorescent properties that ideally match the existing natural dentition under various light sources.

LIP LINE

A high lip line or "smile line" that reveals the entire anterior teeth and large amounts of gingival tissues[7,8] is a great challenge for the dental team since it is impossible hide the implant-restorative interface. A high smile line may be due to vertical maxillary excess or a hypermobile lip.

It is a common rule that, besides being symmetric, the most cervical aspect of the gingival margins of the central incisors should be at the same level as the canines, while the margins of the lateral incisors should be approximately 1 mm below an imaginary line drawn from the canine-centrals-canine.[1] It seems advisable for central incisor implant restorations to initially place the gingival margin slightly more incisally. This slight "overcompensation" will

Case 3 *Continued*

Fig 47 Intraoral try-in of definitive crown under natural light shows an excellent blend with the shade of the adjacent teeth.

Fig 48 Intraoral try-in under UV light demonstrates ideal blending of the fluorescent properties of the definitive crown with the adjacent teeth.

Fig 49 *(Right)* Definitive implant restoration.

Fig 50 Postoperative occlusal view showing the soft tissue support and contour.

Fig 51 The definitive abutment and restoration provide the same degree of fluorescence as a natural tooth.

prove extremely helpful to counterbalance tissue recession typically seen over time. The CTG now becomes an essential aspect for functional and esthetic integration of the implant-supported restoration, especially in the presence of a high lip line.

Occasionally, unfavorable changes of the gingival margin levels may occur at the teeth adjacent to the implant restoration. These are based on the distance between the free gingival margin and the supporting bone and may require more extensive tissue grafting to control gingival levels at both the natural and implant-supported teeth. The added connective tissue causes the fibrotic mucosa around the implant to migrate more coronally. In rare cases, the additional soft tissue becomes so

Case 3 *Continued*

Fig 52 Postoperative view under natural light showing the color match of the implant-supported crown with the natural dentition.

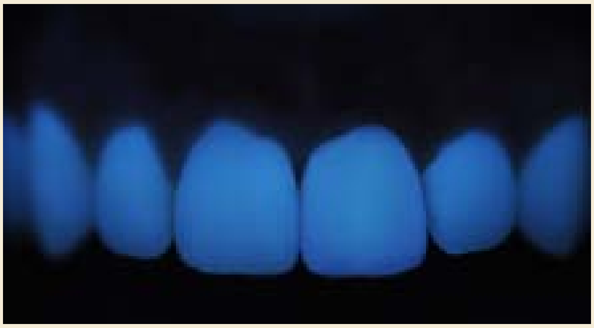


Fig 53 Postoperative view under UV light showing the ideal blend of fluorescent properties between the restoration and natural dentition.

Fig 54 Postoperative intraoral situation. No gray zone is evident.

Fig 55 One-year postoperative periapical radiograph of the implant at the left central incisor site.

abundant that a gingivectomy followed by a fibrotomy becomes necessary to establish ideal crown lengths and gingival margin contours.

The unfavorable umbrella effect is most prevalent in patients with a high smile line.[6] The gray zone may become visible at the implant restoration site even when all of the key factors were perfectly implemented. Differences in soft tissue thickness and volume may cause these color dissimilarities, which are then amplified by the shear presence of the upper lip, causing a shadow on the soft tissue and the light to be reflected and transferred in a different manner.

Case 4

Fig 56 Case 4: Intraoral view of the definitive zirconia abutment..

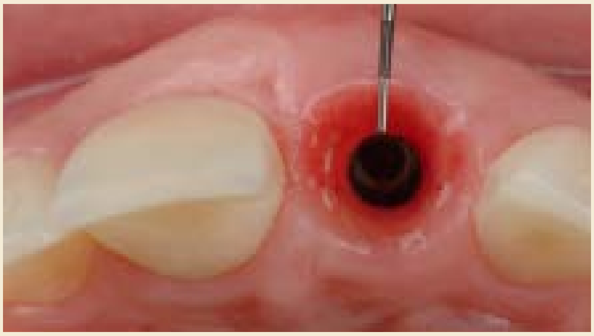


Fig 57 A CTG was placed earlier to ensure ideal soft tissue thickness.

Fig 58 Intraoral situation after 1 year reveals differences in peri-implant soft tissue color and morphology.

Fig 59 Preoperative view showing the patient's high lip line.

Fig 60 Postoperative situation. An unfavorable gray zone is visible during an average smile.

Fig 61 A high smile reveals the gray zone through the umbrella effect.

Case 4 (Figs 56 to 61) demonstrates a situation in which the maxillary left central incisor was replaced with an implant-supported crown in a patient with a high smile line. A CTG was placed to enhance the soft tissue contours. While all of the key aspects were implemented successfully, the slight differences in soft tissue volume created an unfavorable grayish effect (Figs 60 and 61).

Case 5

Fig 62 Case 5: Intraoral view of the crown preparation of the right central incisor and the definitive colored zirconia implant abutment at the left central incisor.

Fig 63 UV light reveals the natural fluorescence of the modified zirconia implant abutment.

Fig 64 Preoperative intraoral view of the failing central incisor crowns.

Fig 65 Postoperative intraoral situation showing the color and soft tissue match.

Fig 66 Initial situation. Note the high lip line.

Fig 67 Successful implementation of the five key factors prevented the appearance of a gray zone despite the high smile line.

In contrast to the previous case, Case 5 (Figs 62 to 67) exemplifies successful implementation of these key factors in a patient with a high lip line for long-term esthetic and functional success.

CONCLUSIONS

Five key factors were identified to avoid the gray zone around maxillary anterior implant restorations: 3D implant placement, soft tissue thickness, abutment selection, crown restoration, and lip line. Mimicking the inherent optical properties, especially fluorescence, of natural teeth with ideal prosthetic implant components and crown materials is fundamental for ultimate restorative and soft tissue esthetics.

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