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## **Esthetic assessments in implant dentistry: objective and subjective criteria for clinicians and patients**

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**ABSTRACT**

In recent years the scientific community has shown a clear interest in the esthetic outcome of implant treatment. The present paper provides an overview of esthetic ratings that have been used in implant dentistry. A distinction can be made between objective evaluations by clinicians and subjective evaluations by patients. The former mainly include midfacial and interproximal soft tissue levels, 2D/3D soft tissue alterations, assessment of the color match between the natural dentition on one hand and the peri-implant tissues and the reconstruction on the other hand, ordinal indices such as the pink and white esthetic score. Patient's needs and judgment may differ from objective indicators of implant success and esthetics. As a result, assessing treatment on the basis of patient-reported outcomes measures (PROMs) should be considered important. Validated questionnaires have been used mainly assessing the impact of oral health on the overall well-being of individuals. The esthetic judgement of patients is usually based on non-standardized questions with varying scoring methods, including Visual Analogue Scales (VAS), Likert and other category scales and open questions. The heterogeneity in scoring systems between studies may compromise proper comparison of objective and subjective esthetic outcomes between studies and therapeutic concepts.

## INTRODUCTION

Ample long-term studies have been published demonstrating successful outcome of dental implants in partially and fully edentulous patients using various treatment protocols ([21](#), [36](#), [44](#), [49](#)). Given the fact that in the early days, implants were mainly used for functional rehabilitation, these papers mainly reported on implant and superstructure survival, marginal bone loss and complication rates. Even though these aspects are of key importance, they are incomplete and merely focus on clinicians' judgement.

In the last decade, the scientific community has shown a clear interest in other aspects of treatment outcomes, which reflect the changing demands of an evolving society. Economic and cost-effectiveness analyses have recently been published ([3](#), [20](#)). The first reports are emerging on the impact on speech of different implant-supported prostheses designs ([74](#)). Moreover, psychosocial parameters have gained considerable attention relating to patient perception of implant treatment and patient preferences ([19](#), [24](#), [69](#)). These aspects are of key importance since they reflect the patient's judgement. Patient's needs and judgment may differ from objective indicators of implant success and survival. Assessing treatment on the basis of patient-reported outcomes measures (PROMs) is an increasingly common aspect of research, in which the evaluation of patient satisfaction is considered crucial.

Esthetics have become a key issue in contemporary practice. The scientific output reflects this phenomenon as the majority of papers on soft tissue aspects in implant dentistry was published in the last decade. In these studies clinicians' as well as patients' critical assessment of esthetics have been reported, sometimes with a distinction between soft tissue esthetics or so-called 'pink' esthetics ([28](#)) and the esthetic appraisal of the superstructure, often referred to as 'white' esthetics ([4](#)).

The objective of the present paper was to provide an overview of esthetic ratings that have been used in implant dentistry.

## MODERN METHODS TO ASSESS ESTHETICS

### **Overview of esthetic ratings used in implant dentistry: the judgement of the clinician**

Esthetic demands of patients, who have been provided with tooth- and implant-borne reconstructions, have increased over the years. Moreover, the development of new materials, new technologies, and enhanced knowledge of the periodontal and the peri-implant biology provided the basis for better esthetic outcomes with fixed tooth- and implant-borne reconstructions. These outcomes can be assessed by objective parameters such as the presence or absence of the papilla, the level of the mucosal margin, 2D and 3D changes of the peri-

implant tissues as well as a reconstruction that matches the color, the shape and the texture of the contralateral natural tooth.

In a recent systematic review, parameters and methods were evaluated for the assessment of esthetics in implant dentistry (5). In this review 181 clinical studies were identified, using one or several methods and parameters evaluating esthetics outcomes of implant therapy. This high number of included studies reflects the efforts and importance of such outcome measures in today's clinical research. It was reported that scoring systems greatly differed between studies, thereby limiting the possibility to compare esthetic outcomes of different studies and therapeutic concepts.

#### *Level of the mucosal margin*

The level of the mucosal margin relative to the contralateral natural tooth site is one of the most frequently used methods to assess esthetic outcomes (1, 11, 31). Most often this measurement is done in millimeter using references such as the cemento-enamel junction (CEJ), the incisal edge/cusp tips of the teeth examined, the implant shoulder or the incisal edge/cusp of the implant reconstruction, or reference marks on standardized stents (10, 32). Apart from metric measurements, semi-quantitative scoring systems were used comparing the level of the mucosal margin of the implant site to a reference tooth site (2, 50, 55). Outcomes were classified into having no difference up to larger differences between the two sites or categorizing into exposition of the crown margin with a simple binomial ranking (yes/no).

#### *Papilla height/embrasure fill*

The height of the papilla next to dental implants is one of the main parameters affecting the esthetic outcome of implant therapy and has been reported in numerous studies (6, 12, 56, 66). The embrasure fill has been assessed in millimeter measuring the distance between the point of contact between two adjacent teeth and the tip of the papilla (32) or by using a scoring system (57). The following landmarks were frequently used as references: CEJ, the incisal edge/cusp of the adjacent teeth, the implant shoulder, the incisal edge/cusp of the implant-borne reconstruction, and standardized stents. The index most often used evaluated the embrasure fill using a semi-quantitative ranking system (35). This index ranks the embrasure fill applying five possible scores: 0 (=no papilla), 1 (= <50% papilla fill), 2 (= >50% papilla fill), 3 (=full papilla present) and 4 (=hyperplastic papilla).

A variety of factors influence the presence or absence of the papilla. These factors include the anatomy of the neighboring tooth/implant, the implant system, the level of the contact point,

the timing of implant placement, and the use of a provisional reconstruction. From a clinical point of view, the vertical distance between the alveolar crest and the contact point to the adjacent tooth appears to most significantly influence the height of the papilla between natural teeth (62). Based on a clinical study analyzing the relationship between this distance and the embrasure fill, the papilla was present in 98% of the cases, when the vertical distance was less or equal to 5 mm. With increasing distances, the percentage of a full papilla decreased continuously. This observation was confirmed in a subsequent study on single implants attributing the embrasure fill between an implant restoration and adjacent tooth to the vertical position of the periodontal attachment of the adjacent tooth (9). In cases where the distance between the contact point and the alveolar crest measured more than 5 mm, the presence of the papilla was reduced to a frequency of 50%. The anatomy at dental implants is substantially different from natural teeth and inserting Sharpey's fibers are missing around dental implants. This finding and the fact that the interdental bone peak resorbs when extracting adjacent teeth for implant placement, may be considered the most important reasons for the reduced papilla height between two dental implants (60). Interestingly, the same applies to papilla between an implant and a pontic and to a smaller extent to papilla between adjacent pontic (15). Apart from the vertical position, the horizontal distance between the implant and the adjacent tooth also plays a role regarding papilla height. Previous scientific evidence suggested a minimal distance of 1.5 mm between a dental implant and a neighboring tooth to be necessary to compensate for remodeling processes following the establishment of the biologic width (26, 27). In case two dental implants are placed next to each other, an optimal distance of 3mm between the two was suggested in order to obtain a normal papilla (61). These observations have been predominantly attributed to the implant design and remodeling processes taking place following implant placement and/or abutment connection. One has to bear in mind, however, that most of these data were obtained using implant systems with a one-piece or two-piece design with a matching implant abutment junction. More recent developments in implant dentistry provided more extensive use of two-piece dental implants with non-matching implant-abutment junctions. In two recent preclinical studies inter-implant distances of 2, 3 and 4mm demonstrated a similar marginal bone loss (22, 23). This indicates that the implant design has an impact on the morphology of the peri-implant tissues. Horizontal distances between two implants and between an implant and a natural tooth might, therefore, have to be reconsidered and evaluated in the future by well-designed clinical studies.

### *2D and 3D changes in soft tissue morphology*

Today, there is neither consensus nor sufficient evidence with respect to the amount of soft tissue volume necessary on the buccal side of a dental implant in order to obtain long-term functional and biological success. Recent studies indicated a relationship between the buccal peri-implant bone height and the level of the mucosal margin (5, 41). Generally speaking, these studies demonstrated slightly more recession with a decreasing buccal bone height. Interestingly, the data demonstrated that peri-implant soft tissues can at least in part compensate for missing buccal bone. From an esthetic point of view and in terms of the color of the peri-implant soft tissues, clinical data suggest a critical bucco-oral soft tissue dimension of 2mm (40, 73). Various clinical studies demonstrated that in cases with less than 2 mm of buccal soft tissue volume, the choice of the reconstruction material can significantly influence the esthetic outcome at implant sites. Moreover, more favorable results were reported for all-ceramic reconstructions compared to metal-ceramic reconstructions (39, 52, 76). This in turn means that in cases of more than 2 mm of soft tissue in buccal-oral dimension, the choice of the reconstructive material will less likely hamper the esthetic outcome (38, 40).

Methods to assess the buccal soft tissues dimensions include the use endodontic files with or without standardized stents and the use of ultrasonic devices. In a prospective case series including 37 patients with single missing teeth, dental implants were placed and the soft tissues augmented with connective tissue grafts (16). The soft tissue thickness was evaluated using an ultrasonic device at various time-points up to one year following implant placement. The data obtained indicated relatively stable soft tissues with a minimal loss of 10%. This type of measurement offers advantages over measurements using endodontic files, since they are non-invasive, they don't interfere with healing and they potentially have better patient acceptance.

To date, little scientific data is available evaluating the peri-implant soft tissues in a three-dimensional way. This is based on the fact that the available techniques to capture volume changes are optimized for hard tissues (cone beam computed tomography; CBCT) or are only occasionally used in dentistry (magnetic resonance imaging; MRI). In order to overcome these shortcomings, a series of preclinical and clinical studies evaluated new techniques to evaluate soft tissue volume changes in a three-dimensional way including intraoral scanners and the corresponding software tools (54, 59, 70). These techniques have been used to quantify soft tissue volume changes in single tooth gaps and to measure the height of the papilla (54, 59). Three-dimensional measurements have rendered high accuracy and reliability and thus offer non-invasive ways to monitor changes of peri-implant tissues resulting from

implant therapy. Apart from assessing the overall three-dimensional volume changes, cross-sectional images allow measuring two-dimensional soft tissue dimensions at various levels below the marginal mucosa (53, 75). Recent scientific evidence demonstrated 3D soft tissue volume changes over time to highly correspond to two-dimensional measurements (65, 75).

#### *Color of the peri-implant mucosa and the reconstruction*

The appearance of tooth- and implant-borne reconstructions remains a crucial factor for esthetic success. The color match of peri-implant tissues and reconstructions to that of the natural dentition has been described as one of the greatest challenges. Difficulties in color match are attributed to the fact that dental implants and natural teeth as well as the surrounding soft and hard tissues differ. Clinically, the use of spectrophotometers has been demonstrated to be one of the best standardized tools to assess the color match: i) between the peri-implant mucosa and the gingiva of the contralateral/adjacent tooth and, ii) between the reconstruction and natural crown contralateral/adjacent tooth. A spectrophotometer allows an objective evaluation of the soft tissue color of tissues and reconstructions. It records digital images that are used for spectral analysis. The data of the measurements are calculated and displayed on the indications of the *Commission Internationale de l'Éclairage* (CIE), with L = lightness, a = chroma along red-green axis, and b = chroma along yellow-blue axis (48). Images of test sites and control sites are captured and color differences are calculated. This technique was originally introduced as a color measuring tool for dental composite veneers and their surrounding tooth structure (34). Subsequently, a variety of clinical and in vitro studies applied spectrophotometric outcome measures to analyze different materials for dental implants and implant-borne reconstructions on the level of the mucosa. Color differences were calculated between metal and alumina-reinforced abutments, between metal and zirconia abutments, between zirconia and veneered zirconia abutments and between titanium and zirconia dental implants (6, 38, 40, 67, 76). Even though sensitive spectrophotometric measurements may reveal color differences, clinically, these materials and reconstructions may still fulfill esthetic expectations and subjectively please the needs of patients and clinicians. This discrepancy indicates that for the optical perception of color differences, additional factors might have an influence. Based on one study, a clinical threshold value for the visibility of color differences ( $\Delta E$ ) by the naked eye of 3.7 was calculated (37). Under standardized laboratory conditions a color difference of about  $\Delta E=1$  in the CIELAB system was defined as a threshold for visibility of color differences (42). More recently, threshold values were recalculated for the gingiva and the tooth substance/reconstruction in

standardized settings. The obtained threshold values indicated that i) on the level of the mucosa/gingiva, lay people, dental technicians and dentists have a different perception for color alterations of the gingiva. The overall threshold (pooled data for lay people, dentists and technicians) for gingival color differences amounted to a mean of  $\Delta E = 3.1 \pm 1.5$  (51); ii) on the level of the tooth/reconstructions, lay people, dental technicians and dentists have a similar perception for changes of the tooth color. The overall combining threshold for tooth color differences amounted to a median  $\Delta E$  of 1.8. (64).

#### *Pink esthetic score/white esthetic score/implant crown esthetic score*

In the past, efforts were made to combine a number of parameters and suggest esthetic scores. The primarily applied indices include the pink esthetic score (PES) (28), the white and pink esthetic score PES/WES (4) and the implant crown esthetic index (ICEI) (46). These three scores can serve as objective measures to assess the esthetic outcomes of implant therapy, at least when evaluating single implants. They can either be applied directly in a clinical setting or on standardized photographs. The PES includes a total number of seven items: the mesial papilla, the distal papilla, the level of the soft tissue margin, the soft tissue contour, possible alveolar process deficiencies, the soft tissue color, and the soft tissue texture. For each implant site, a score of 0 to 2 (0 being the worst, 2 being the best value) is given resulting in a maximum score of 14. This index was later combined with an analysis of the reconstruction and led to the so-called PES/WES scoring system. The PES/WES includes 10 items: mesial papilla, distal papilla, curvature of the facial mucosa, level of the facial mucosa, root convexity/soft tissue color/texture (PES), general tooth form, outline and volume of the clinical crown, color, surface texture, translucency and characterization (WES). A maximum score of 20 can be obtained (2 points for each item). The clinical acceptability threshold of 6 has been proposed for both PES and WES. Similarly, the ICEI includes the peri-implant soft tissue and parameters related to the reconstruction. The reconstructive parameters encompass the mesio-distal dimension of the crown, the position of the incisal edge, the labial convexity of the crown, the color and translucency of the crown, the position of the labial margin of the peri-implant mucosa, the position of the mucosa in the interproximal embrasures, the contour of the labial surface of the mucosa, as well as the color and surface of the labial mucosa. All these three indices have been applied in numerous studies and are well-accepted for assessing esthetic outcomes (18, 29, 47, 63, 72) (7).

#### **Esthetics as a patient-reported outcome measure: the judgement of the patient**

Reports on patients' perception of implant treatment have gained considerable interest in recent years. This evolution seems logic taking into account that patients need to function with a prosthesis. Thus, their final evaluation should be considered pivotal, even if such assessment is subjective and therefore difficult to quantify.

Several terms have been used in the literature to express patients' perception of implant treatment, such as patient satisfaction, patient centered outcomes and patient reported outcomes. In the eighth European Workshop on Periodontology, the term PROMs (Patient Reported Outcome Measures) was introduced (43, 45). These essentially include 'subjective' reports of patients' perceptions of their oral health status and its impact on their daily life or quality of life (1), reports of satisfaction with oral health status and/or oral health care (2), and other non-clinical assessments (3) (43).

Esthetics is an important PROM and can be assessed in many ways. Non-standardized questions are frequently used for this purpose with varying scoring methods, including Visual Analogue Scales (VAS), Likert and other category scales and open questions (17). Although the information that comes from such non-standardized questions may be valuable from an exploratory point of view, the validity and reliability of this 'ad hoc' approach may be questionable. As a result, it may be difficult, if not impossible to compare studies on the basis of such questions. Validated questionnaires that have been used in implant dentistry are 'Oral Health Impact Profile' (OHIP-49 with 49 standardized questions and OHIP-14 with 14 standardized questions) (58) and 'Oral Health Related Quality of Life' (OHRQoL) (71). Both have been developed to assess the impact of oral health on the overall well-being of individuals and include some questions relating to esthetic aspects. In a recent report, it was proposed to use existing generic health PROMs (such as the OHRQoL) as a framework to develop standardized implant-specific PROMs (43).

A systematic review has recently been published on the use of PROMs in implant dentistry (17). Apart from the heterogeneity in reporting, a number of factors have been identified that could introduce a certain bias into the conclusions on PROMs. For one thing, it does not seem clear in a lot of studies if patients actively sought implant treatment, if they were dissatisfied with their existing prostheses, or if they paid for the treatment. In addition, patients were asked to evaluate treatment under varying conditions. Ideally, this should be performed in a separate room without the clinician being present, yet such information is rarely described and may have been violated in a number of studies. As a result of all these factors, the true esthetic appreciation of patients has probably been overestimated so far.

Patients in need of a single anterior implant may be more critical than fully-edentulous patients because of proportionally higher costs and esthetic concerns. Apart from that, it also has to be stressed that surgical and technological advancement may increase patients' expectations. This especially applies to modern implantology and the treatment of partially edentulous patients, which has increasingly become esthetically-driven. Indeed, ridge preservation, connective tissue grafts, 3D implant planning, guided surgery, provisional restorations and CAD-CAM technology are frequently used for anterior rehabilitations ([13](#), [14](#), [16](#), [33](#), [68](#)). All these advancements substantially increase patients' costs, making them even more critical from an esthetic point of view than they already are. Figure 1 and 2 show clinical examples of patients with high esthetic demands in need of an anterior rehabilitation. Future studies should continue to evaluate PROMs by using a standardized approach and focusing on partially-edentulous patients. According to a recent systematic review abundant data are available on fully-edentulous patients treated with a mandibular implant overdenture. However, all other types of prostheses have been underexposed to research ([17](#)).

(HERE APPROXIMATELY FIGURE 1 AND 2 PLEASE)

### **OBJECTIVE VERSUS SUBJECTIVE ASSESSMENT OF ESTHETICS**

In a number of clinical studies mainly relating to single tooth implants, objective esthetic scores have been compared to subjective esthetic scores. Already in 1999, 41 single implant restorations in 29 patients were esthetically evaluated by prosthodontists and by patients ([8](#)). It was concluded that clinicians were more critical than patients in judging esthetics. Furthermore, factors considered by professionals to be of significance for the esthetic outcome appeared not to be of decisive importance for patients' satisfaction.

More recent studies with data on larger patient samples confirmed these findings. Meijndert and co-workers (2007) evaluated 93 patients that had been treated with bone augmentation and a single implant ([47](#)). Clinicians were less satisfied than patients with respect to the esthetic outcome. In addition, both professionals as patients rated the soft tissue outcome as less satisfactory than the implant crown. The authors could not find a correlation between the Implant Crown Aesthetic Index and patient questionnaires.

Cosyn and co-workers (2013) evaluated the outcome of 104 single tooth implants after on average 2.5 years of function ([13](#)). A weak correlation between the pink esthetic score and patient's esthetic appraisal of the peri-implant mucosa was found. The same applied to the

correlation between the white esthetic score and patient's esthetic appraisal of the implant crown.

Esposito and co-workers (2009) compared clinicians' and patients' judgement of esthetics on the basis of 30 pre- and postoperative pictures. The overall agreement between patients and clinicians and also among clinicians was poor (25). Interestingly, it has been described that the dental specialisation may have a significant impact on the intra- and inter-observer agreement of the pink esthetic score (28, 30). In this respect, orthodontists seem most critical and reproducible in assessing esthetics.

## CONCLUSIONS

Implant and superstructure survival, marginal bone loss and complications are important parameters to assess the outcome of implant treatment. However, esthetics have become a key issue in contemporary practice and therefore esthetic evaluations should be included in clinical research. Clinicians as well as patients can judge the esthetic outcome of therapy in a number of ways. Although all may be valuable from an exploratory point of view, the heterogeneity in scoring systems between studies may compromise proper comparison of esthetic outcomes between studies and therapeutic concepts.

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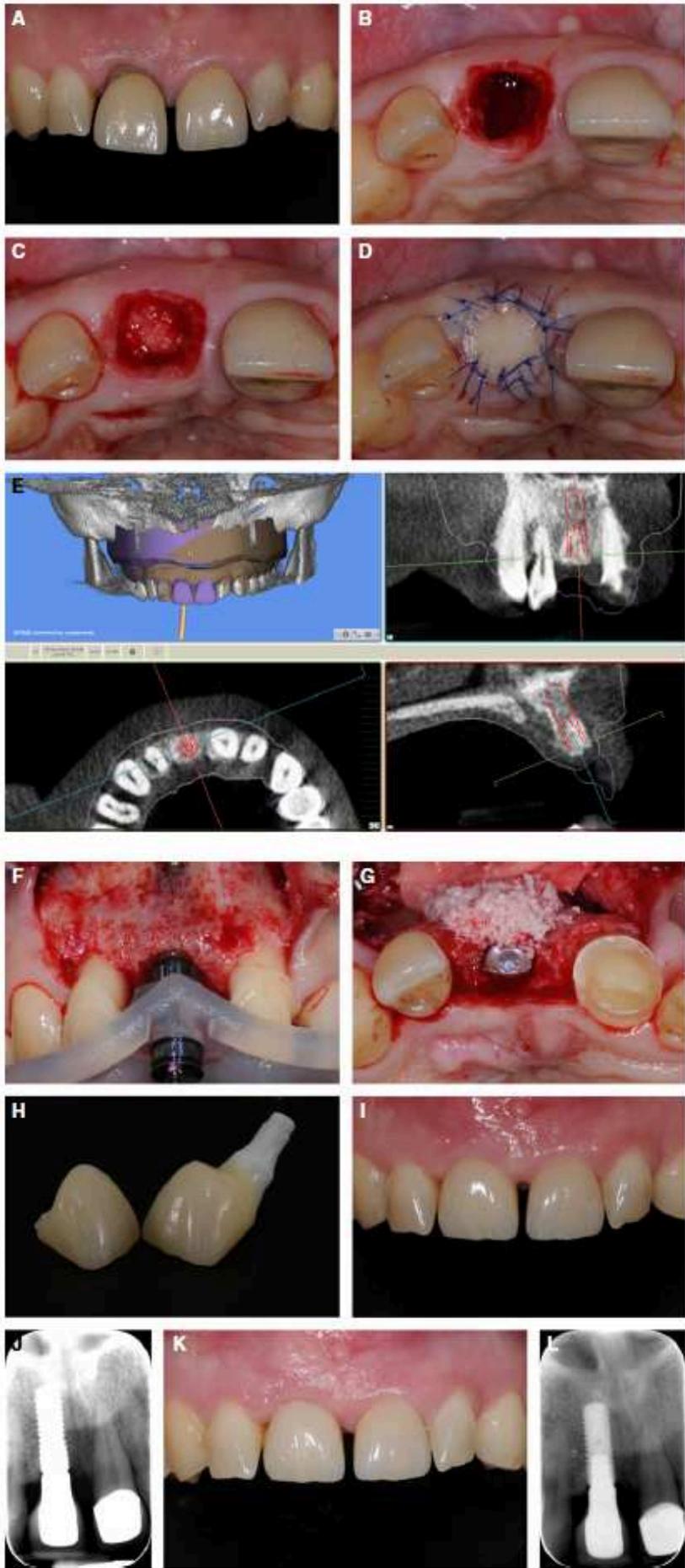


Figure 1

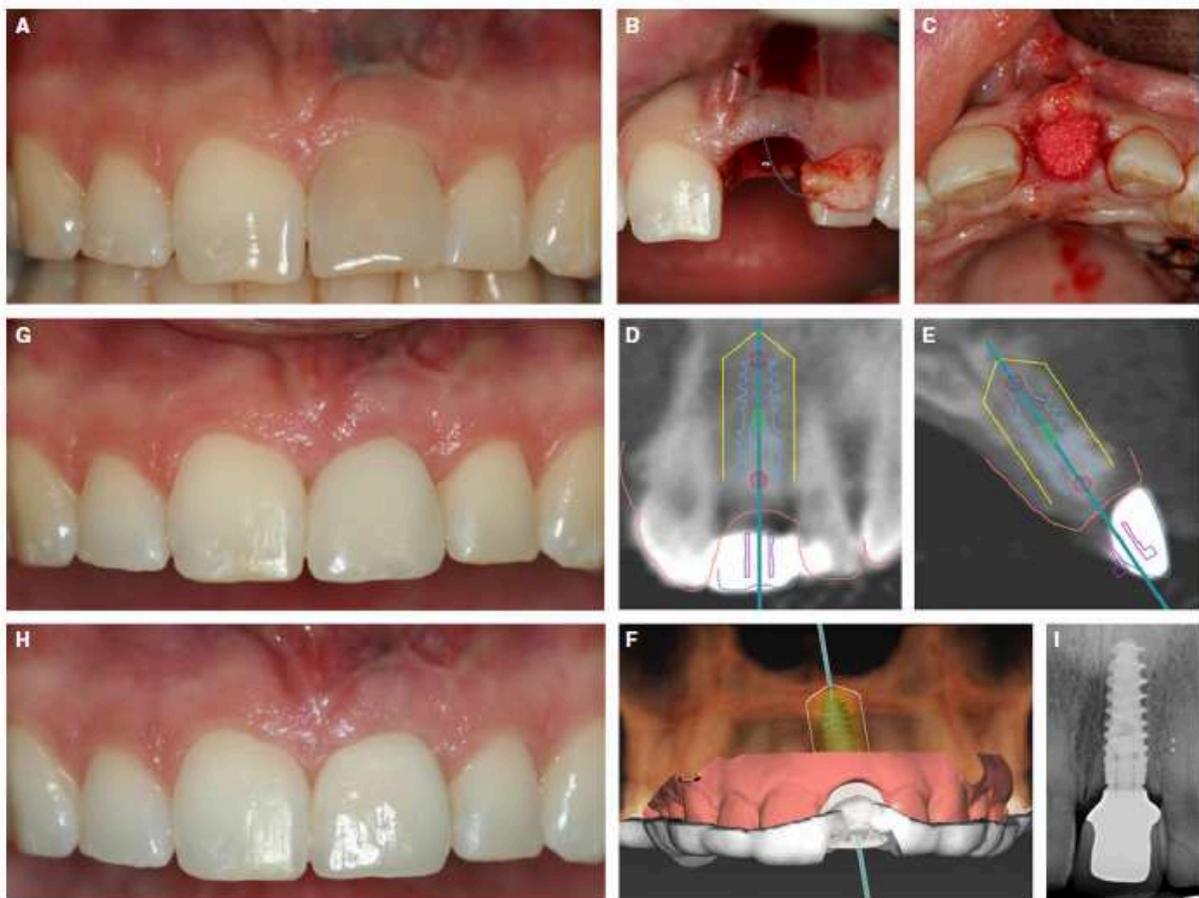


Figure 2