

Clinical Variables for Successful Esthetic Outcomes of Implant Prosthodontics

Ignacio Pedrinaci, Elli Kotina, Neil Griseto, Adam Hamilton, German O. Gallucci

DOI: 10.3290/iti.fi.45622

Abstract

Achieving an ideal esthetic outcome with implant-supported rehabilitation of missing teeth is a challenging procedure, especially in the anterior zone. Numerous clinical variables have been reported to impact the ultimate treatment outcome. Thus, a comprehensive understanding of the anatomic, biologic, surgical, prosthetic and patient-centered factors must be pursued to obtain an optimal and predictable result. This article summarizes most of the variables contributing to esthetic and biological success in implant prosthodontics of the anterior zone and to provide key treatment considerations on the decision-making process of replacing missing anterior teeth with dental implants.

Introduction

Achieving esthetic success with implant replacement of missing teeth is often a challenge. Predictable results can be achieved when adequate diagnosis is performed, together with selection of scientifically supported treatment principles. Several clinical variables have a substantial impact on the treatment outcome of fixed implant-supported rehabilitation in the anterior maxilla zone. Thus, implant treatment planning in the esthetic zone should entail a comprehensive understanding of anatomic, biologic, surgical, prosthetic and maintenance principles (Belser, Buser & Higginbottom 2004; Buser, Martin & Belser 2004; Gallucci, Guex et al. 2007; Higginbottom et al. 2004; Martin et al. 2014; Ntounis et al. 2015).

The use of dental implants in the esthetic zone should ideally aim at achieving a natural looking implant-prosthodontic complex integration in harmony with the adjacent dentition (white esthetics) and gingival tissues (pink esthetics) (Furhauser et al. 2005; Belser et al. 2009).

In this context, the ITI SAC Classification in Implant Dentistry aims to provide clinicians with a systematic assessment for dental implant therapy in the esthetic zone (SAC classification, risk assessment 2009 - Adapted from the ITI's SAC Classification in Implant Dentistry 2nd Edition, 2021).

Patient perspectives should be regarded with caution (Stefanini et al. 2018). Esthetic risk variables should be communicated and addressed with the patient before treatment to avoid any post-treatment misunderstandings that may occur in the case of a final compromised outcome that would not meet the patient's expectations. For these reasons, the ITI's Esthetic Risk Assessment (ERA) suggests pretreatment evaluation of the parameters affecting both surgical and prosthetic procedures in the esthetic area. This is an exceptional communication and educational tool for both clinician and patients (Buser, Martin & Belser 2004; Belser, Buser & Higginbottom 2004; Higginbottom et al. 2004). Several other treatment strategies addressing

optimal implant placement and restoration in the esthetic zone have also been presented (Martin et al. 2014; Morton et al. 2014; Morton et al. 2018).

The objective of this article is to evaluate the variables that influence success in implant prosthodontics in the esthetic zone and to provide key treatment considerations for the decision-making process when replacing missing anterior teeth with dental implants.

Site-related variables

a. Smile line

Among the extraoral factors, the smile line seems to be a natural starting point (Fig. 1). A combination of precise surgical and restorative techniques should be followed to obtain soft tissue esthetic integration and natural-looking restorations. This fact is of major importance in patients with a high smile line since they have a relatively higher risk due to a complete gingival display when smiling.

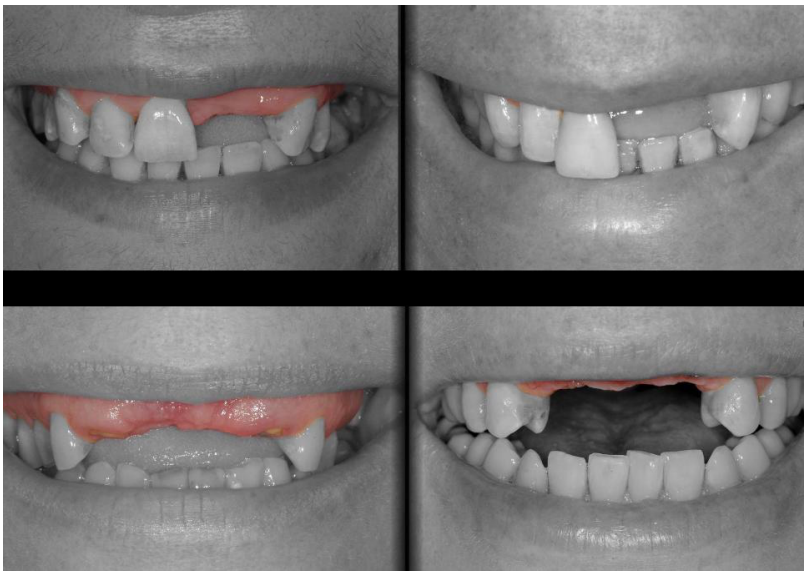

Fig. 1: The four different configurations of anterior edentulous gap size – smile line relationship. Top left: asymmetric edentulous gap with a medium smile line. Top right: asymmetric edentulous gap with a low smile line. Bottom left: symmetric edentulous gap with a high smile line. Bottom right: symmetric edentulous gap with a medium smile line

Conversely, restorative factors will be of greater importance than soft tissue on medium gingival-display patients, and the presence and display of the papilla should be the most relevant factors on patients with low lip lines. Regardless, the smile line remains a critical site-related variable. Clinicians should aim for ideal esthetic integration irrespective of the smile-line level, since patients with a low smile line may also have high esthetic expectations.

Information on the gingival display of the patient combined with a diagnostic tooth set-up will help with decision-making when: a) compensating for volumetric defects by prosthetic means using pink ceramics (in low smile-line cases) or b) vertical ridge reconstruction (restoration margins are in full display from the high smile line). In some scenarios, orthodontic tooth extrusion of hopeless teeth can be also employed to optimize the available tissue (Salama et al.

1993; González-Martín et al. 2020).

b. Attachment level of adjacent teeth

Maintenance of the peri-implant papilla depends largely on the attachment level of the adjacent teeth (Fig. 2). Thus, a single edentulous space with proper gingival attachment constitutes an optimal site for implant placement. In contrast, when there are multiple missing teeth, it is well understood that anatomically correct papillae are less likely to be observed following treatment. The planning of the implant position as well as the implant-abutment junction location and type will influence the peri-implant soft tissue stability. The distance between the crestal bone adjacent to the dental implant and the contact point of the future restoration or the cementoenamel junction (CEJ) of the adjacent tooth is a well-studied measurement (Gallucci et al. 2004; Belser et al. 2009; Rocuzzo et al. 2018). Implants of reduced diameter, with longer and narrower transmucosal components allowing for a narrow emergence profile have been demonstrated to better preserve the peri-implant tissues (Galindo-Moreno et al. 2014; Blanco et al. 2018; de Souza et al. 2018).

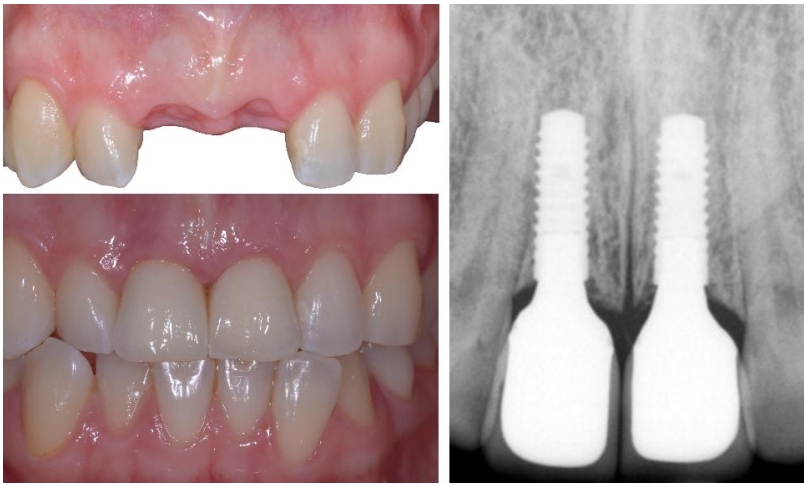

Fig. 2: Top left: the preoperative situation of missing maxillary central incisors with minimal attachment loss at the adjacent teeth. The radiograph shows how an optimal implant postion respecting the necessary distance between implants and from the adjacent teeth. Bottom left: final implant restoration showing harmonious integration with the existing natural dentition

c. Periodontal phenotype

The next consideration must be the evaluation of the periodontal phenotype prior to implant placement, which can be assessed by digital superimposition of the STL and DICOM files (Couso-Queiruga et al. 2021). Patients with thick gingival phenotypes are often characterized by a wide band of keratinized tissue. Here, special attention should be paid to sites with a thin gingival phenotype because they are associated with a higher risk of future recession or transmucosal visibility of subgingival metallic components. Thin gingival phenotypes are also commonly associated with thin facial alveolar bone thickness. In turn, thin bone phenotypes (buccal bone thickness ≤ 1 mm) are associated with greater alveolar bone resorption (Chappuis et al. 2013; Avila-Ortíz et al. 2020; Couso-Queiruga et al. 2021).

d. Bone profile of the edentulous site

The anatomical profile of the edentulous site will have a major impact on the esthetic outcome of dental implants (Fig. 3). The oro-facial width of the edentulous site will determine the implant diameter and the need for use of biological materials to ensure an esthetic and stable result. The mesio-distal dimension of the site should ensure a minimum distance of 1.5 mm between implant and adjacent teeth and 3 mm inter-implant (Grunder et al. 2005).

Fig. 3: The influence of tooth shape (restorative space) in determining the implant size and position. The picture on the left with a rather tringular shape calls for a more apical implant placement and a narrower emergence profile. The picture on the right, with a rather rectangular shaped tooth would allow for a more coronal implant position

The corono-apical dimension remains a critical factor as it may affect treatment planning in two important ways. The first is the total amount of vertical bone height for implant placement. The second relates to any vertical site deficiencies in relation to the ideal proposed buccal-mucosal margin position. Site deficiencies in the esthetic zone may affect esthetic results, and appropriate reconstructive techniques may be necessary to obtain an ideal implant position. Horizontal bone augmentation procedures will improve the soft tissue profile in a very predictable manner (Buser et al. 2013), while vertical bone augmentation procedures are less predictable, and operator-dependent for success.

Diagnostic, planning, surgical, and prosthodontic steps will commonly need to be adapted to the specific characteristics mentioned below (Fig. 4). For this purpose, a conventional, or ideally, a digital workflow may enhance the treatment outcomes and facilitate a predictable esthetic result (Gallucci et al. 2019).

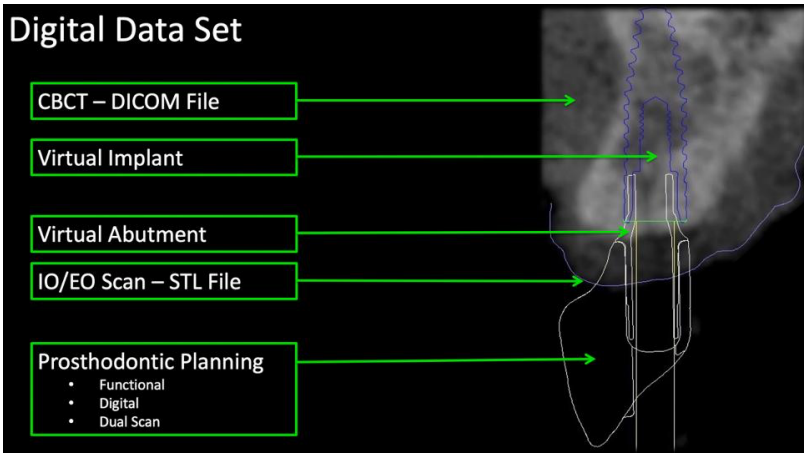

Fig. 4: Digital data set for implant prosthodontic planning in the esthetic area

Surgical-related variables

a. Implant placement & loading protocol

Treatment planning in the context of implant therapy – implant diameter, length, three-dimensional position, placement, and loading protocol – should be assessed prior to tooth extraction (if the tooth is still present), particularly in the anterior esthetic zone. Hence, the selection of the implant placement and restoration/loading protocol should be based on achieving predictable long-term hard and soft tissue stability, optimal esthetics, reduced risk for complications, and also meet patient-specific and site-related criteria.

The 6th ITI Consensus Conference reviewed the available evidence for the clinical outcome of fixed implant prostheses treated with different combinations of implant placement and loading protocols (Gallucci et al. 2018).

The possibilities for dental implant placement include:

1 - Immediate implant placement post-extraction

2 - Early implant placement with soft tissue healing (8-12 weeks)

3 - Early implant placement with partial bone healing (12-16 weeks)

4 - Late implant placement (more than 6 months post-extraction)

The possibilities for dental implant loading include:

A - Immediate loading/provisionalization (< 48 hours)

B - Delayed loading (1 - 8 weeks)

C - Conventional loading (> 8 weeks) after placement

Immediate implant placement with immediate restoration/loading (type 1A) (Fig. 5) may be considered when there are patient-centered advantages (e.g., esthetic requirements, reduced morbidity), and when several pre-operative and intrasurgical conditions are met:

- Intact socket walls
- Facial bone thickness of at least 1 mm
- Thick soft tissue

- No acute infection at the site
- The availability of bone apical and lingual to the socket to facilitate primary stability
- Insertion torque 25 – 40 Ncm and/or ISQ value >70
- An occlusal scheme that allows for protection of the provisional restoration during function
- Patient compliance

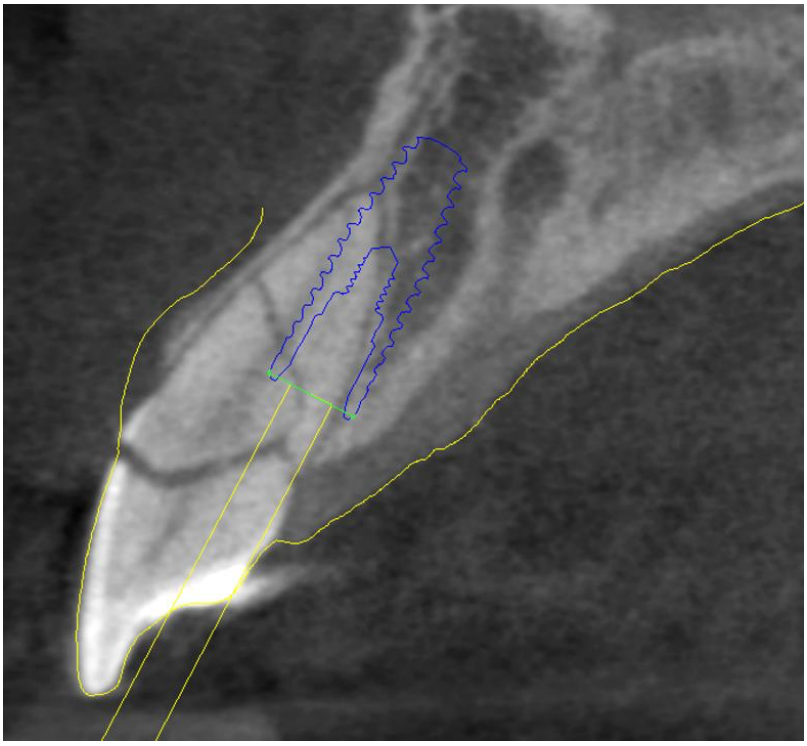

Fig. 5: Optimal case selection and implant planning for placement protocol 1A: -> Intact socket walls -> Facial bone of at least 1 mm in thickness -> No acute infection at the site -> At least 3 mm of bone apical and lingual to the socket to provide primary stability -> Thick soft-tissue phenotype

However, only short-term follow-up to scientifically validate this protocol is available (Cosyn et al. 2016; Blanco et al. 2019). Early implant placement (Type 2) may be considered in most clinical situations, such as sites with thin facial walls and defects that often require simultaneous bone augmentation procedures. Type 2-3C was scientifically and clinically validated showing excellent survival and success results in a long-term follow-up (Buser et al. 2013). Late implant placement (Type 4B-C) is a clinically and scientifically valid protocol. However, it is the least desirable of the placement time options, due to the risk of alveolar ridge resorption and reduction in bone volume, in addition to extended treatment time. When late placement is indicated for patient- or site-related reasons, an alveolar ridge preservation procedure may be recommended to facilitate a less invasive and predictable future esthetic restoration (Gallucci et al. 2018).

b. Implant design

Implant design has been a factor discussed for successful replacement of missing teeth in the esthetic area. The use of tissue level implants in the esthetic zone has been reported in the literature (Siebert et al. 2018). However, bone level implants offer several advantages over the former in the esthetic zone. Among these advantages are a) preservation of the facial bone wall

coronal to the implant shoulder – bone remodeling originated by the smooth surface will no longer be present. b) a greater range of tolerance for abutment height adaptation according to the supracrestal tissue height, c) simultaneous reconstruction of the facial bone wall coronal to the implant shoulder during implant installation, (Buser et al 2013), and d) future change of the abutment if soft tissue recession occurs.

In the anterior maxilla in particular, the use of tapered implants may be beneficial to avoid fenestration defects, and implants with special thread design (large anchoring surface) may be beneficial to increase initial insertion torque in favor of immediate implant placement.

c. Implant diameter

The most appropriate implant diameter will be dependent on the edentulous span to restore and the residual alveolar crest of the area. Thus, preservation of the peri-implant buccal bone wall has been correlated with long-term peri-implant health (Spray et al. 2000; Monje et al. 2019) and reduced horizontal space to neighboring teeth to get an adequate emergence profile. Narrow diameter implants (NDIs) were shown to be effective when replacing a single tooth in non-load bearing regions. Reinforced titanium implants such as TiZr (Roxolid®) are recommended to improve fracture resistance (Altuna et al. 2016; Benic et al. 2013). When placing an immediate implant, NDIs contribute to maintaining the integrity of the labial bone and a facial gap > 2 mm that can be filled with a slow resorption material so a future tissue collapse can be anticipated (Vignoletti et al. 2014; Sanz et al. 2017). Wide diameter implants are not generally recommended in the anterior maxilla due to an associated increased risk of peri-implant soft tissue deficiencies and subsequent esthetic complications (Chen & Buser 2009).

d. Three-dimensional implant position

Obtaining a successful outcome when treating an edentulous space with dental implants in the esthetic area will be largely dependent on the three-dimensional implant position. Since the level of the interproximal papilla is partly related to the bone level height of the adjacent teeth, which in turn is affected by the implant-tooth and implant-implant distance, a space of 1 - 1.5 mm between the implant shoulder and the proximal root must be respected. This distance must be increased to 3 mm between adjacent implants. Respecting these distances might reduce the interproximal crestal bone loss and enable the establishment of the necessary vertical distance between the contact point and bone crest and contribute to the presence of papillae (Salama et al. 1998; Tarnow et al. 2000; Cardaropoli et al. 2003).

In determining the ideal coronal position of the implant, a digital tooth set-up determines the most apical boundaries of the intended restoration. Enough vertical space should then be allocated for the transmucosal component connecting the crown with the implant (Fig. 6). The following formula could be used:

“Most apical boundary of intended restoration + running space + mucosal height of the abutment = vertical implant position“

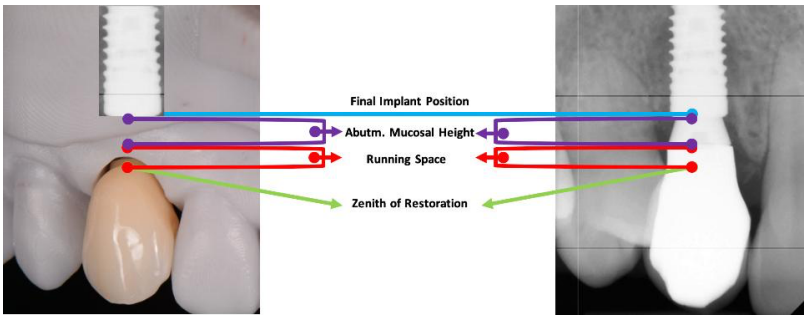

Fig. 6: Graphic representation of the formula used to determine the ideal implant position in the esthetic zone: Most coronal boundary of intended restoration (green) + running space (red) + mucosal height of the abutment (purple) = vertical implant position (blue)

It has been demonstrated that the labio-palatal position of the implant in the esthetic zone plays a fundamental role in esthetic outcomes (Fig. 7). Wide-diameter implants (Chen & Buser 2009), buccal angulation of the implant, or implants too buccally positioned have a higher risk of soft tissue dehiscence (Sanz-Martín et al. 2020; Romandini et al. 2021). Also, implants placed too palatally result in undesirable emergence profiles (Steigman et al. 2014; Chu et al. 2019). Therefore, it is recommended that the implant axis should be located 1 mm palatal to the incisal edge so a screw-retained restoration is feasible. This will allow the clinician to maintain retrievability of the implant-supported crown with direct screw access, and therefore the possibility to modify the interim prosthesis to obtain an ideal emergence profile.

Fig. 7a: Type 4 implant placement: Para-crestal incision

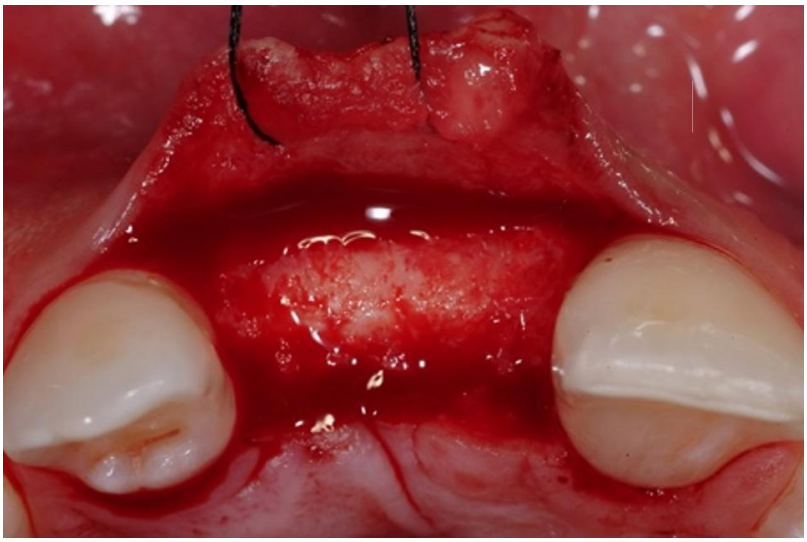

Fig. 7b: Type 4 implant placement: Ideal alveolar ridge

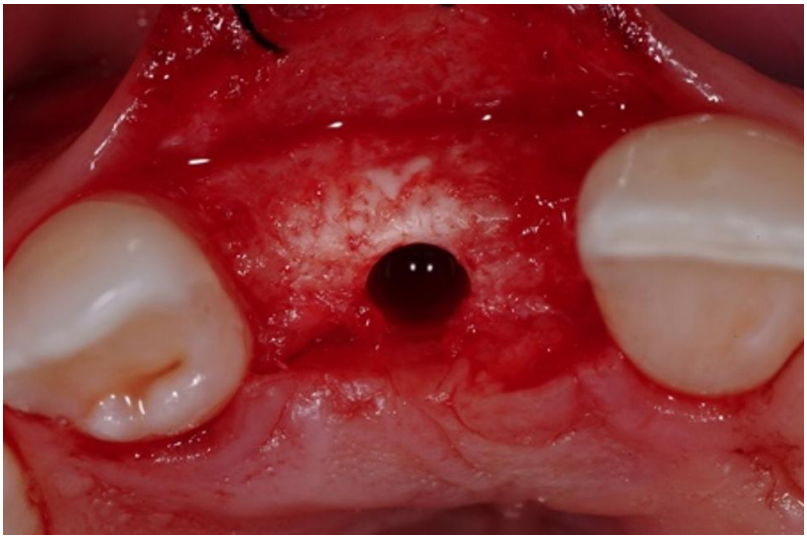

Fig. 7c: Type 4 implant placement: Optimal implant bed preparation allowing for thick buccal bone

Digital implant planning allows the clinician to choose a suitable implant and abutment with precision before following the aforementioned biological concepts. Digital surgical guides can substantially reduce human error in contrast to freehand implant placement. Following this line, we can maximize the ideal 3D position in accordance with the treatment plan (Gallucci et al. 2019; Marei et al. 2019).

e. Incision design

The incision design may have an esthetic implication specially when a scar line is displayed during smiling. The flapless approach offers many benefits when pursuing ideal esthetic outcomes. It simplifies the procedure, minimizes interproximal or buccal bone remodeling, avoids scar tissue due to vertical releasing incisions, and maintains papilla height at its original level (Stoupel et al. 2016). Other advantages include a) reduction of surgical time and need for suturing, b) maintenance of blood supply from the periosteum and supraperiosteal plexus, c)

reduction of patient morbidity in terms of bleeding, swelling, pain, and d) shorter healing periods (Brodala et al. 2009). Nevertheless, this approach is recommended when enough keratinized mucosa is present in the area, computer-guided surgery is used to guide the position of the implant, and there is sufficient native bone to compensate for errors from the guided implant placement.

Conversely, elevating a flap may allow for a paracrestal incision in a more palatal position resulting in the vestibular displacement of the flap to maintain or increase the amount of available keratinized mucosa buccally. Furthermore, advanced flap procedures have been designed to treat gingival recession or increase the soft tissue volume on teeth and restoration next to the augmented edentulous ridges (Palacci et al. 2008, Canullo et al. 2018).

f. Bone and soft tissue augmentation procedures

Bone and soft tissue augmentation procedures will be of paramount importance to maintain long-term esthetic integration (Figs 8 - 12). Some clinical indications for soft tissue augmentation procedures include compensation of soft tissue deficiencies, prevention of future mucosal defects or tissue adaptation at implant placement for esthetic purposes. For example, the absence of a vestibular bone plate and the presence of a thin peri-implant phenotype are risk factors for recession of peri-implant tissues. A minimum amount of keratinized mucosa width (≥ 2 mm) is recommended for optimal peri-implant health and long-lasting clinical outcomes (Gobbatto et al. 2013; Ávila-Ortiz et al. 2020; Tavelli et al. 2021). It is also important to note that mucosal thickness has a significant role when selecting abutment material. Hence, it is suggested that a minimum thickness of 2 mm is necessary so the human eye can’t detect any discoloration of the mucosa due to the underlying material (Jung et al. 2008; Lops et al. 2017; Ávila-Ortiz et al. 2020).

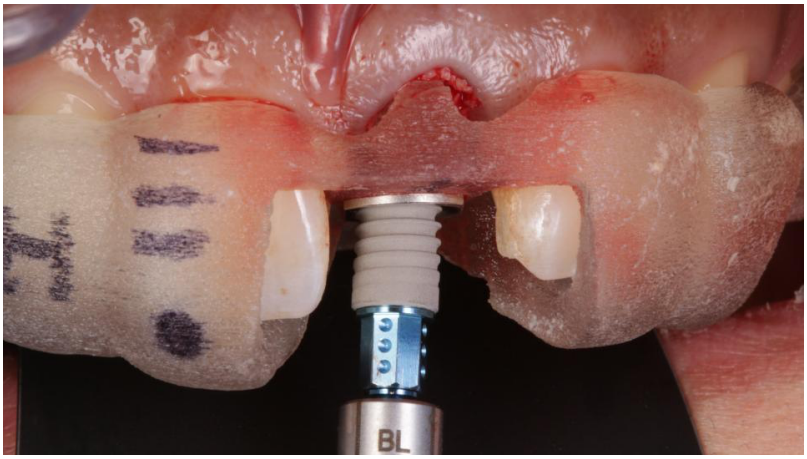

Fig. 8a: Type 1 implant placement: Guided implant placement into extraction socket

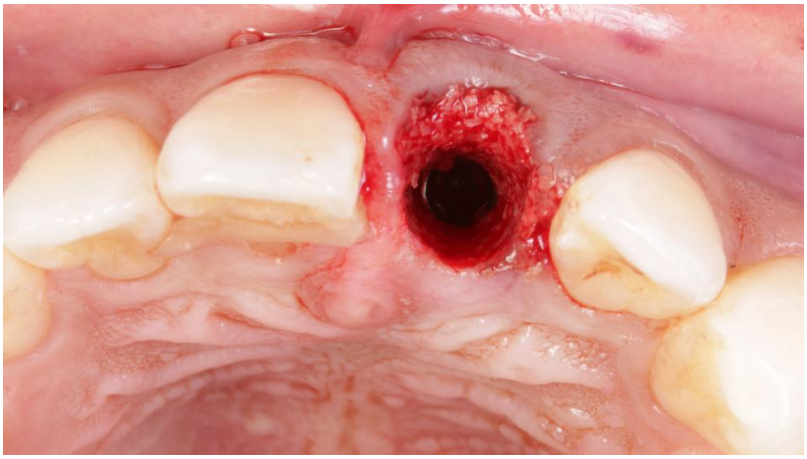

Fig. 8b: Type 1 implant placement: Bone grafting of the buccal gap

Fig. 8c: Type 1 implant placement: Socket sealing technique (SSA)

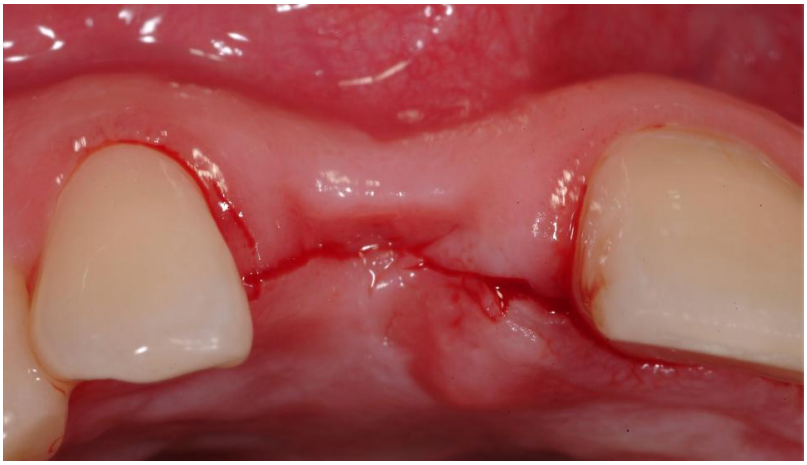

Fig. 9a: Type 2 implant placement: Mid-crestal incision

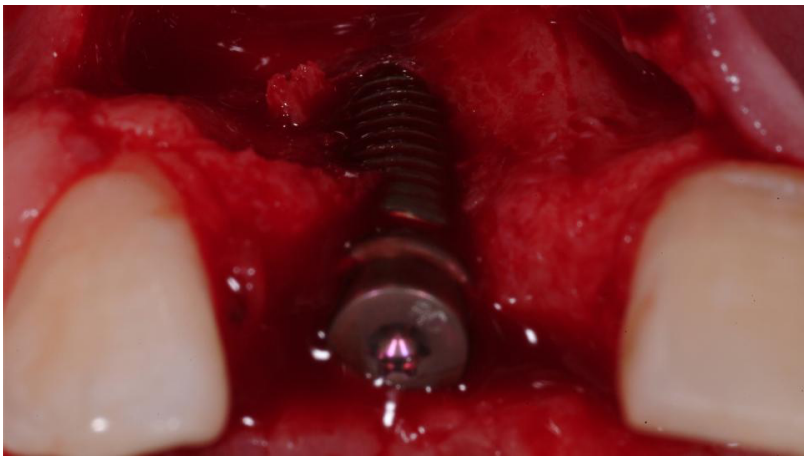

Fig. 9b: Type 2 implant placement: Reabsorbed alveolar ridge

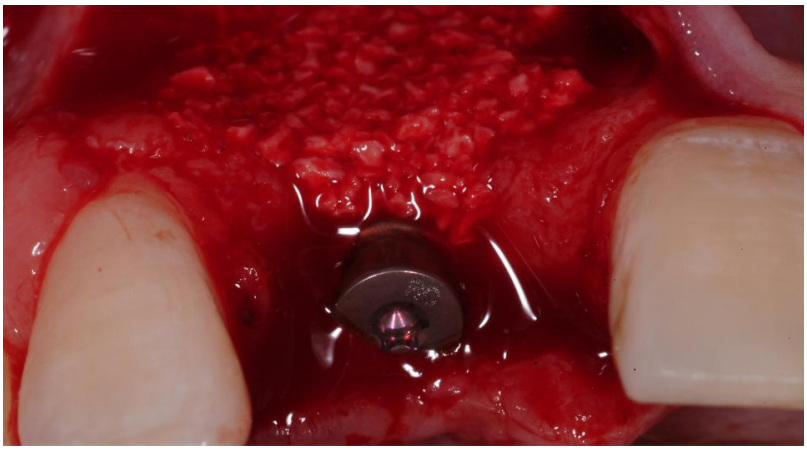

Fig. 9c: Type 2 implant placement: Optimal implant bed preparation with contour augmentation

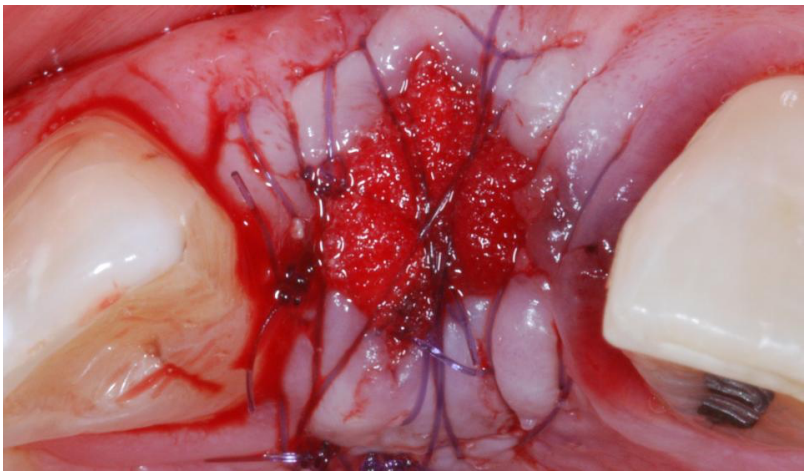

Fig. 10a: Ridge preservation + Type 4 implant placement: Ridge preservation at the time of tooth extraction

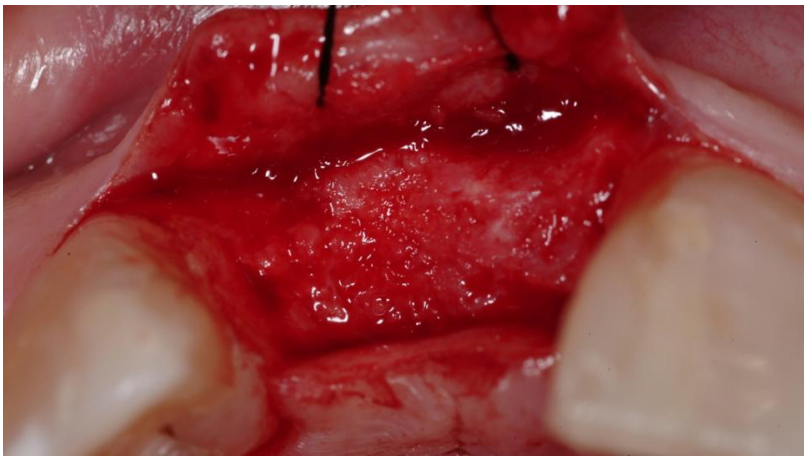

Fig. 10b: Ridge preservation + Type 4 implant placement: Ideal alveolar ridge healing after GBR

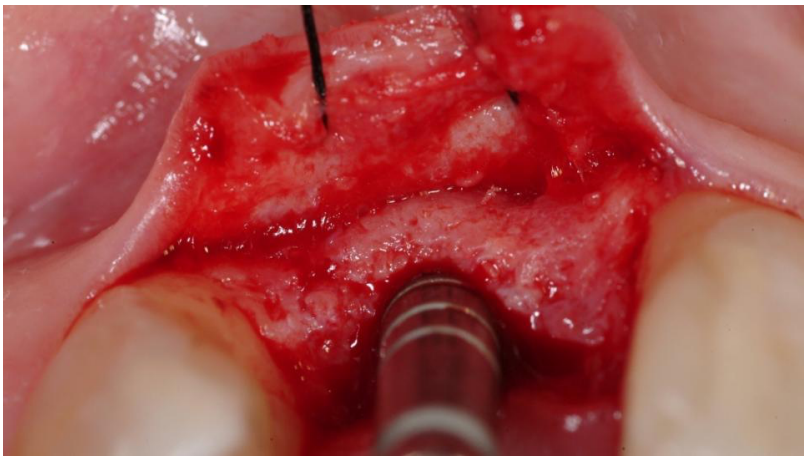

Fig. 10c: Ridge preservation + Type 4 implant placement: Optimal implant bed preparation allowing for a thick buccal bone

Fig. 11a: Block grafting + Type 4 implant placement: Ridge vertical and horizontal deficiency

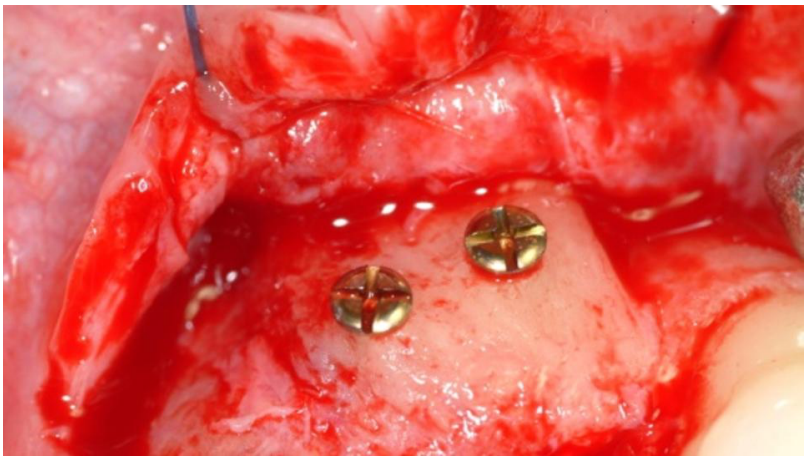

Fig. 11b: Block grafting + Type 4 implant placement: Ideal alveolar ridge healing after block bone grafting

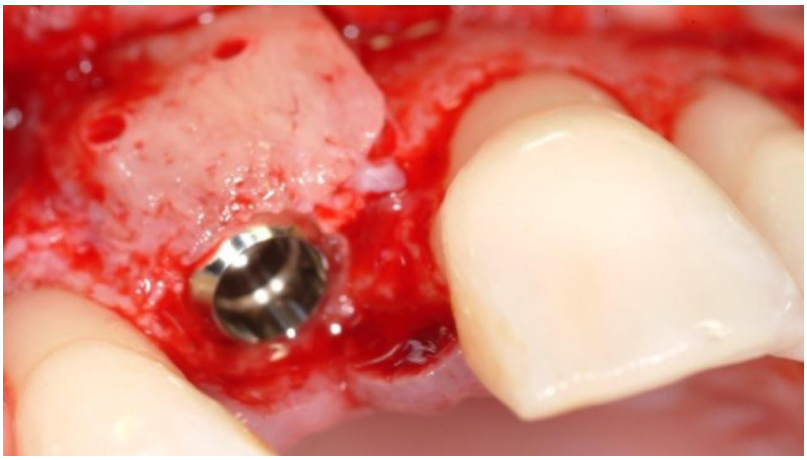

Fig. 11c: Block grafting + Type 4 implant placement: Optimal implant bed preparation allowing for a thick buccal bone

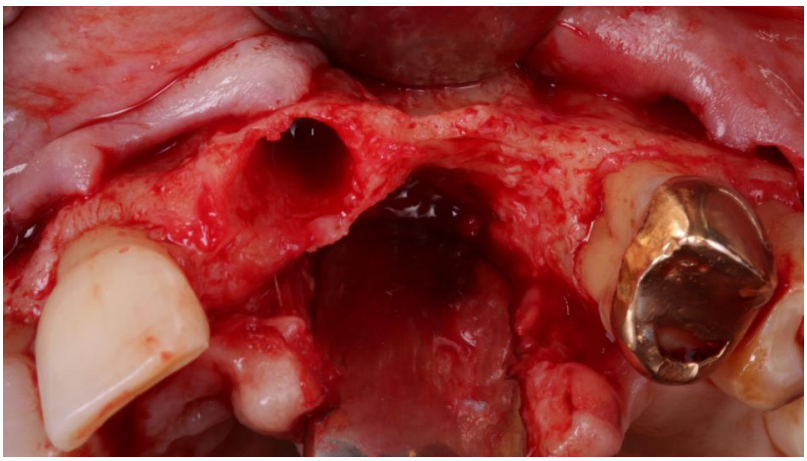

Fig. 12a: Horizontal and vertical bone grafting + Type 4 implant placement: Ridge vertical and horizontal deficiency

Fig. 12b: Horizontal and vertical bone grafting + Type 4 implant placement: Particulate bone grafting

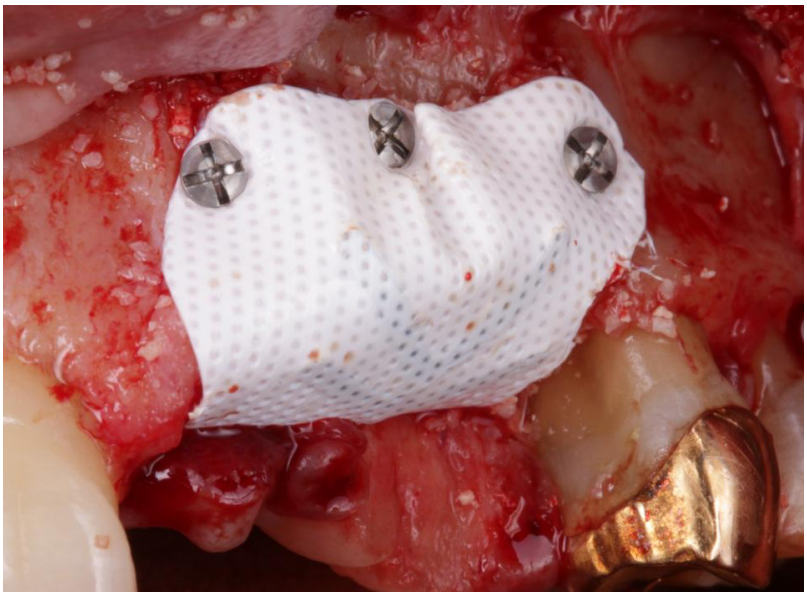

Fig. 12c: Horizontal and vertical bone grafting + Type 4 implant placement: Titanium reinforced membrane

When improving unsatisfactory ridge deformities generated by horizontal bone deficiencies, ridge augmentation procedures via Guided Bone Regeneration (GBR) are preferred over soft tissue augmentation procedures. GBR – like soft tissue grafting – can be performed at the time of implant placement, or prior to implant placement as a separate, staged procedure (Sanz-Sánchez 2015). Increasing the peri-implant bone – particularly at the coronal level – will assist in preventing future bone loss around the implant, which is critical for long-term stability of the obtained outcomes (Grunder et al. 2005; Monje et al. 2019). Vertical ridge augmentation of the lost bony structure allows the placement of the implant shoulder in a more coronal position to thus decrease the crown height of the implant prosthesis, obtaining a natural appearance when restoring an edentulous space in the esthetic area (Urban et al. 2019) (Fig. 12). These procedures are less predictable and alternative treatment options may also be contemplated.

Thus, any bone grafting procedure performed prior to or at implant placement should ideally render a dimensionally stable buccal bone volume (Fig. 13).

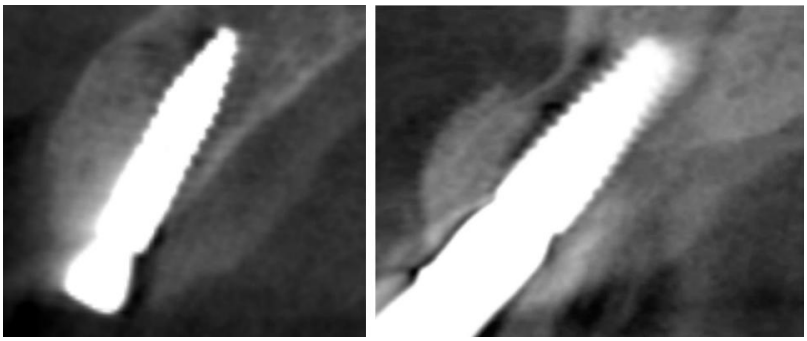

Fig. 13: Post-surgical CBCTs of two different cases of implant placement in association with GBR illustrating stable buccal bone. Left: Immediate post-op of type 1 implant placement. Right: 6-year follow-up of type 2 implant placement

Restoration-related variables

The restorative component of an implant rehabilitation constitutes a predominant variable in the treatment success. In esthetic dentistry, the symmetry, shape, contour, and texture of the restoration is key to obtaining a successful result (Gallucci, Guex et al. 2007).

a. Anatomically correct emergence profile

During and after the healing phase, the development of a correct emergence profile should guarantee a harmonious transition between the implant fixture and restoration. Thus, different techniques of conditioning peri-implant soft tissues have been described including immediate provisional restorations, custom healing abutments and provisionalization after osseointegration (Wittneben et al. 2013; Finelle et al. 2015; Doliveux, Jamjoom, Nadra et al. 2020; Elian et al. 2007; Joda et al. 2016; Kurbad & Kurbad 2013; Papaspyridakos et al. 2020; Hassan, Greven & Wismeijer 2017).

Prerequisites for establishing the ideal emergence profile should be considered:

- The contour of the emergence profile is determined by the position and angulation of the implant; therefore, ideal 3D implant placement would be the first requirement that assures adequate space for the soft tissue. Misplaced implants will compromise ideal conditions, leading to alterations in the peri-implant hard and soft tissues (Esquivel et al. 2021).
- Adequate space needed for the reestablishment of the supracrestal tissue attachment around the implant (Buser, Martin & Belser 2004; Tarnow et al. 2000; Zamzok 1997).
- Tissue thickness is a critical factor for the integration and establishment of the supracrestal tissue attachment and therefore, the shape of the emergence profile (Linkevicius et al. 2018; Linkevicius et al. 2015).
- The final contour of the provisional restoration is essential to achieve an esthetic result. Any alteration of the contour the implant transmucosal part of the abutment and crown can modify the final soft tissue profile.
- Customized conventional impression copings, or digitally scanning the transitional gingival zone of the provisional are key to capturing and transferring the ideal shape of the developed emergence profile to the final restoration (Doliveux, Jamjoom, Nadra et al. 2020;

Monaco et al. 2016; Joda et al. 2014).

One easy way to understand the ideal approach to managing the peri-implant soft-tissue is to divide the emergence profile into three different zones (Fig. 14): The incisal zone (a), the transitional zone (b) and the cervical zone (c).

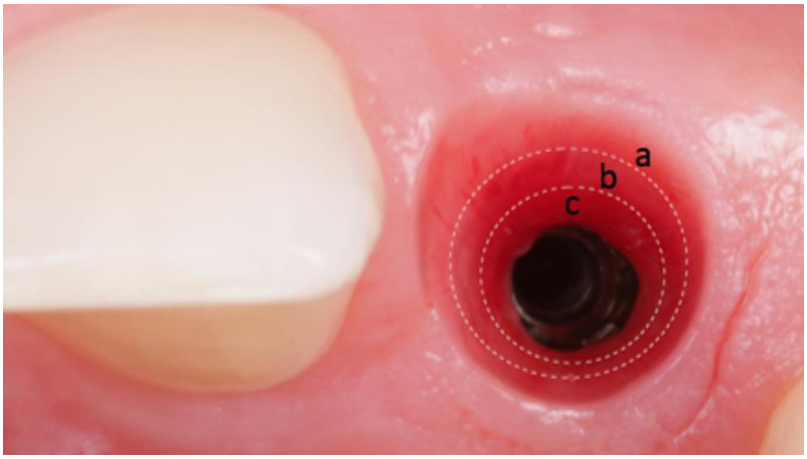

Fig. 14: Soft tissue modeling by the provisional implant restoration in lateral incisor position, conditioning an anatomically correct emergence profile. Management of the emergence profile divided into three zones: incisal zone (a), transitional zone (b), cervical zone (c)

The A zone of the emergence profile is critical for the final esthetic contour of the implant-supported crown. It should be convex, supporting the soft tissue, and imitate the shape of the crown of the extracted or the contralateral natural tooth. The clinician should take into consideration that overcontouring of this zone would cause apical soft tissue displacement. The B zone is the transition zone that connects the C with the A zone and its primary role is to provide the appropriate space for soft tissues. The C zone is critical for crestal stability, it must be well designed and allow space for the soft tissues (Finelle et al. 2015; Souza et al. 2018).

b. Implant abutment

The selection of an implant abutment in the anterior region is related to the following factors: thickness of the peri-implant mucosa, implant angulation, restoration material, interocclusal space, type of the restoration, and the retention mechanism (Bidra & Rungruanganunt 2013; Zarauz et al. 2021; Sailer et al. 2009; Linkevicius & Vaitelis 2015). In general, there are two main categories: a) prefabricated titanium abutments are accepted as the gold standard because of their clinical success, their biocompatibility, and advanced mechanical properties. However, particularly for anterior restorations, b) custom abutments designed individually with CAD/CAM technology provide optimal esthetics, function and tissue stability (Doliveux, Jamjoom, Finelle et al. 2020).

The selection of the abutment material and its related mechanical properties should ensure optimal esthetic integration while providing mechanical strength to the implant-restoration complex (Totou et al. 2021; Vafiadis 2008; Vetromilla et al. 2019; Wittneben et al. 2017; Zarauz et

al. 2021; Zembic et al. 2014).

c. Retention mechanism

In the esthetic zone, screws are the preferred retention mechanism (Wittneben et al. 2017; Wittneben et al. 2013; Martin et al. 2014; Sailer et al. 2012). This calls for an implant position in a prosthetically ideal orientation with the future screw-access hole lingual to the incisal edge in order to facilitate screw channel location that does not compromise the esthetics and function of the prosthesis. Screw-retained FDPs have the advantage of predictable retrievability. They require a minimal amount of interocclusal space (min. 4 mm) and enable the removal of the prosthesis for periodontal maintenance, prosthesis repair or surgical access requirements. Angulated screw channel (ASC) abutments are a versatile solution to overcome a minor buccal inclination of the implant position to maintain lingual screw access (Wang et al. 2021).

d. Characteristics of the final restoration

The characteristics of the final restoration are one of the most significant variables to achieve optimal esthetic outcomes. The most widespread restorative options for single-unit implant crowns include porcelain fused to metal (PFM), lithium disilicate, layered zirconia and full-contour zirconia. Each option has indications and limitations as follows (Pjetursson et al. 2021; Pjetursson et al. 2018; Morton et al. 2018):

- PFM crowns are a reliable choice for implant crowns (Fig. 15). However, this technique is being slowly discontinued by dental technicians and replaced by metal-free and digital workflows (Edelhoff et al. 2019).
- Lithium-disilicate-reinforced glass ceramic crowns have shown exceptional mechanical and esthetic properties on tooth-supported reconstructions (Fig.16). Translucency is one of the most highlighted characteristics of this material. This material is often mounted on a prefabricated titanium base (ti-base) abutment.
- Layered zirconia ceramic restorations are a valid treatment alternative to metal ceramic implant restorations for single crowns with similar biological complications but enhanced esthetics (Fig. 17).
- Monolithic zirconia offers enhanced mechanical properties for implant restorations, but modifications are needed to optimize esthetics (Sadowsky 2020). A modified monolithic design implemented with minor cut-back limited to the facial surface of the crown, allows restorative space for the veneering porcelain to enhance esthetics and avoid porcelain chipping from occlusal bearing surfaces, the most frequent technical complication. Recent advances in the fabrication of multi-layered zirconia blocks enable total monolithic design without cut-back, making the use of monolithic zirconia in the esthetic zone more reliable (De Angelis et al. 2021; Ueda et al. 2015).

Fig. 15: Porcelain-fused-to-metal (PFM) implant crown

Fig. 16: Zirconia prefabricated abutment with layered ceramic

Fig. 17: Titanium base prefabricated abutment with a lithium-disilicate crown

For partial edentulous fixed implant-supported dentures (FPDs) when more than two anterior teeth are missing, careful consideration should be given to the selection of the restorative material (Sailer et al. 2007; Sailer et al. 2018; Pjetursson et al. 2017).

- Whereas metal-ceramic FPD remains the “gold standard” material for the fabrication of multiple-unit-implant or tooth-borne FDPs, zirconia-based reconstructions have gained increasing popularity, as they might provide patients with metal-free reconstructions of higher esthetics at a lower price. Chipping of the veneering zirconia frameworks has been a frequently reported problem (Sailer et al. 2018).
- An alternative to the layered restorations with porcelain is the application of monolithic types of reconstructions (Gintaute et al. 2021). New, more translucent and/or colored types of zirconia ceramics have been introduced, reducing the need for veneering ceramics. Monolithic zirconia reconstructions are a promising alternative to the zirconia-ceramic reconstructions and may exhibit lower rates of ceramic chipping . Monolithic design or

modified monolithic design with only facial cut-back aids in eliminating porcelain chipping. Adequate connector size is also crucial to increase the fracture strength of zirconia (Papaspyridakos et al. 2020).

Regardless of the material used for the final restoration, a design allowing for adequate plaque control is required.

Discussion

This article highlights the key factors that have been clinically and scientifically demonstrated to optimize and favor long-term stability for implant esthetic outcomes.

The recently revised Esthetic Risk Assessment (ERA) is a valuable educational, treatment and communication tool that should be considered as the gold standard when clinicians strive for state-of-the-art treatment planning in the esthetic area. Esthetics are a patient-reported outcome measure and those patients with unrealistic expectations and high esthetic risk must be recognized. Thus, further comprehensive understanding of different aspects such as age, gender, socioeconomic, education level and clinical variables should be included to improve the impact of implant rehabilitation on patients' quality of life.

An ideal esthetic outcome is the result of interaction between the patient, site, and surgical and restorative variables. Given that all these variables are interconnected, the clinician should always start treatment planning by considering the osseointegrated implant as part of the final prosthesis (Gallucci, Mavropoulos et al. 2007).

Prosthetically driven implant placement is essential to ensure the required restorative space for the prosthetic components, while biologically driven prosthesis placement allows the establishment of an ideal peri-implant phenotype which guarantees predictable long-term results.

In brief, the success and stability of an esthetic outcome is an inevitable combination of critical factors that involve (summarized in Table 1):

- Interdisciplinary team approach and meticulous treatment planning
- Consideration of patient perceptions and expectations
- Preoperative prosthetic planning and risk factor assessment
- Implementation of digital technology for diagnostic and planning accuracy: restorative and biologically driven implant placement
- Careful execution of the surgical and prosthodontic phase
- Maintenance, education and monitoring of the patient

Variables	Relevance	Clinical considerations	Treatment plan considerations
Site-related			
Smile line	High	Higher esthetic risk with high smile line	Pink vs soft tissue and bone augmentation
Attachment level of the adjacent teeth	High	Presence of periodontal attachment loss	Interproximal space closure
Periodontal phenotype	Medium	Higher risk of future recession or transparency in thin phenotypes	Phenotype modification
Anatomical profile of the edentulous site	Medium	Inadequate site to guarantee a predictable long term implant restoration	Augmentation procedures and NDI
Surgical variables			
Implant placement and loading protocols	High	Several conditions needed to perform predictable immediate placement	Follow long-term and scientifically validated protocol
Implant design	Low	Tissue level implants are highly dependent on site and 3D position	The use of bone level implants simplifies the procedure
Implant diameter	Medium	Wide implants have a higher risk of hard and soft tissue remodeling	Use NDI or augmentation procedures to preserve peri-implant soft tissues
Three-dimensional implant position	High	Undesirable tissue remodeling and retention mechanism	Digital surgical guides can maximize the ideal 3D position in accordance with the treatment plan
Incision design	Low	Unavoidable collapse of soft tissue when raising a flap	Flapless approach when possible
Bone and soft tissue augmentation procedures	Medium	Inadequate tissues lead to higher probability of future bone loss and deficient soft tissue integration	Increasing the peri-implant bone & soft tissues
Prosthetic variables			
Anatomically correct emergence profile	High	Inappropriate contour of transmucosal part (convex or a flat shape) of abutment or restoration affects the final soft tissue configuration and stability	Configuration of emergence profile individualized based on the implant position. In ideally 3D placed implants, a concave supracrestal contour assures the necessary space for long-term stable soft tissue
Implant abutment	Medium	Titanium abutments cause significantly more soft tissue discoloration than ceramic. Fracture of the ceramic abutment more common in the neck area of the internally connected one-piece abutments	Custom CAD/CAM abutments with individualized anatomical contour can effectively improve the esthetic and biologic response
Retention mechanism	Medium	Cement-retained restorations can cause biologic complications and have retrievability limitations	Screw-retained restorations or angulated screw channel (ASC) abutments have the advantage of predictable retrievability
Characteristics of the final restoration	High	Metal-ceramics can have an esthetically compromised outcome	All-ceramic restorations or monolithic with facial veneering restorations are the material of choice
Patient satisfaction/expectation	High	High expectations in an esthetically complicated case would cause low patient experience and satisfaction	"Esthetic risk assessment" treatment guide is a valuable communication and educational tool

Table 1:

References

Altuna, P., Lucas-Taulé, E., Gargallo-Albiol, J., Figueras-Álvarez, O., Hernández-Alfaro, F. & Nart, J. (2016) Clinical evidence on titanium-zirconium dental implants: a systematic review and meta-analysis. *International Journal of Oral and Maxillofacial Surgery* **45**: 842 - 850.

Avila-Ortiz, G., Gonzalez-Martin, O., Couso-Queiruga, E. & Wang, H. L. (2020) The peri-implant phenotype. *Journal of Periodontology* **91**: 283 - 288.

Belser, U. C., Grütter, L., Vailati, F., Bornstein, M. M., Weber, H. P & Buser, D. (2009) Outcome evaluation of early placed maxillary anterior single-tooth implants using objective esthetic criteria: a cross-sectional, retrospective study in 45 patients with a 2- to 4-year follow-up using pink and white esthetic scores. *Journal of Periodontology* **80**: 140 - 151.

Belser, U., Buser, D. & Higginbottom, F. (2004) Consensus statements and recommended clinical procedures regarding esthetics in implant dentistry. *International Journal of Oral & Maxillofacial Implants* **19 Suppl**: 73 - 74.

Benic, G. I., Gallucci, G. O., Mokti, M., Hämmerle, C. H., Weber, H. P. & Jung, R. E. (2013) Titanium-zirconium narrow-diameter versus titanium regular-diameter implants for anterior and premolar single crowns: 1-year results of a randomized controlled clinical study. *Journal of Clinical Periodontology* **40**: 1052 - 1061.

Bidra, A. S. & Rungruanganunt, P. (2013) Clinical outcomes of implant abutments in the anterior region: a systematic review. *Journal of Esthetic and Restorative Dentistry* **25**: 159 - 176.

Blanco, J., Pico, A., Caneiro, L., Nóvoa, L., Batalla, P. & Martín-Lancharro, P. (2018) Effect of abutment height on interproximal implant bone level in the early healing: A randomized clinical trial. *Clinical Oral Implants Research* **29**: 108 - 117.

Blanco, J., Carral, C., Argibay, O. & Liñares, A. (2019) Implant placement in fresh extraction sockets. *Periodontology 2000* **79**: 151 - 167.

Brodala N. (2009) Flapless surgery and its effect on dental implant outcomes. *International Journal of Oral & Maxillofacial Implants* **24 Suppl**: 118 - 225.

Buser, D., Chappuis, V., Kuchler, U., Bornstein, M. M., Wittneben, J. G., Buser, R., Cavusoglu, Y. & Belser U. C. (2013) Long-term stability of early implant placement with contour augmentation. *Journal of Dental Research* **92 Suppl**: 176S - 182S.

Buser, D., W. Martin, & U. C. Belser, U. C. (2004) Optimizing esthetics for implant restorations in the anterior maxilla: anatomic and surgical considerations. *International Journal of Oral & Maxillofacial Implants* **19 Suppl**: 43 - 61.

Canullo, L., Tronchi, M., Kawakami, S., Iida, T., Signorini, L. & Mordini, L. (2019) Horizontal Bone Augmentation in the Anterior Esthetic Area of the Maxilla Using a Flap Design Adapted from Mucogingival Surgery in Association with PLA Membrane and β-TCP. *International Journal of Periodontics & Restorative Dentistry* **39**: 195-201.

Cardaropoli, G., Wennström, J. L. & Lekholm, U. (2003) Peri-implant bone alterations in relation to inter-unit distances. A 3-year retrospective study. *Clinical Oral Implants Research* **14**: 430 - 436.

Chappuis, V., Engel, O., Reyes, M., Shahim, K., Nolte, L. P. & Buser, D. (2013) Ridge alterations post-extraction in the esthetic zone: a 3D analysis with CBCT. *Journal of Dental Research* **92 Suppl:** 195S - 201S.

Chappuis, V., Engel, O., Shahim, K., Reyes, M., Katsaros, C. & Buser, D. (2015) Soft Tissue Alterations in Esthetic Postextraction Sites: A 3-Dimensional Analysis. *Journal of Dental Research* **94 Suppl**: 187S - 193S.

Chen, S. T. & Buser, D. (2009) Clinical and esthetic outcomes of implants placed in postextraction sites. *International Journal of Oral & Maxillofacial Implants* **24 Suppl**: 186 - 217.

Chu, S. J., Kan, J.Y., Lee, E. A., Lin, G. H., Jahangiri, L., Nevins, M. & Wang H. L. (2019) Restorative Emergence Profile for Single-Tooth Implants in Healthy Periodontal Patients: Clinical Guidelines and Decision-Making Strategies. *International Journal of Periodontics & Restorative Dentistry* **40**: 19 - 29.

Cosyn, J., Eghbali, A., Hermans, A., Vervaeke, S., De Bruyn, H. & Cleymaet R. (2016) A 5-year prospective study on single immediate implants in the aesthetic zone. *Journal of Clinical Periodontology* **43**: 702 - 709.

Couso-Queiruga, E., Stuhr, S., Tattan, M., Chambrone, L. & Avila-Ortiz, G. (2021) Post-extraction dimensional changes: A systematic review and meta-analysis. *Journal of Clinical Periodontology* **48**: 126-144.

Couso-Queiruga, E., Tattan, M., Ahmad, U., Barwacz, C., Gonzalez-Martin, O. & Avila-Ortiz, G. (2021) Assessment of gingival thickness using digital file superimposition versus direct clinical measurements. *Clinical Oral Investigations* **25**: 2353 - 2361.

De Angelis, P., Gasparini, G., Rella, E., De Angelis, S., Grippaudo, C., D'Addona, A. & Manicone, P. F. (2021) Patient Satisfaction with Implant-Supported Monolithic and Partially Veneered Zirconia Restorations, *Biomed Research International* **2021**: 1 - 8.

Doliveux, S., Jamjoom, F. Z., Finelle, G., Hamilton, A. & Gallucci, G. O. (2020) Preservation of Soft Tissue Contours Using Computer-Aided Design/Computer-Assisted Manufacturing Healing Abutment with Guided Surgery in the Esthetic Area: Case Report. *International Journal of Oral & Maxillofacial Implants* **35**: e15 - e20.

Doliveux, S., Jamjoom, F. Z., Nadra, M., Gallucci, G. O. & Hamilton, A. (2020) Fabrication technique for a custom implant emergence profile on 3D printed casts. *Journal of Prosthetic Dentistry* **123**: 571 - 575.

Edelhoff, D., Schweiger, J., Prandtner, O., Stimmelmayr, M. & Güth, J. F. (2019) Metal-free implant-supported single-tooth restorations. Part I: Abutments and cemented crowns. *Quintessence International* **50**: 176 - 184.

Elian, N., Tabourian, G., Jalbout, Z. N., Classi, A., Cho, S. C., Froum, S., & Tarnow, D. P. (2007) Accurate transfer of peri-implant soft tissue emergence profile from the provisional crown to the final prosthesis using an emergence profile cast. *Journal of Esthetic and Restorative Dentistry* **19**: 315 - 315.

Esquivel, J., Meda, R. G. & Blatz, M. B. (2021) The Impact of 3D Implant Position on Emergence Profile Design. *International Journal of Periodontics & Restorative Dentistry* **41**: 79 - 86.

Finelle, G., Papadimitriou, D. E. V., Souza, Katebi, N., Gallucci, G. O. & Araujo, M. G. (2015) Peri-implant soft tissue and marginal bone adaptation on implant with non-matching healing abutments: micro-CT analysis, *Clinical Oral Implants Research* **26**: e42 - e46.

Furhauser, R., Florescu, D., Benesch, T., Haas, R., Mailath, G. & Watzek, G. (2005) Evaluation of soft tissue around single-tooth implant crowns: the pink esthetic score. *Clinical Oral Implants Research* **16**: 639 - 644.

Galindo-Moreno, P., León-Cano, A., Ortega-Oller, I., Monje, A., Suárez, F., Óvalle, F., Spinato, S. & Catena A. (2014) Prosthetic Abutment Height is a Key Factor in Peri-implant Marginal Bone Loss. *Journal of Dental Research* **93 Suppl**: 80S - 85S.

Gallucci G. O., Belser, U. C., Bernard, J. P. & Magne, P. (2004) Modeling and characterization of the CEJ for optimization of esthetic implant design. *International Journal of Periodontics and Restorative Dentistry* **24**: 19 - 29.

Gallucci, G. O., Guex, P., Vinci, D. & Belser, U. C. (2007) Achieving natural-looking morphology and surface textures in anterior ceramic fixed rehabilitations. *International Journal of Periodontics & Restorative Dentistry* **27**: 117 - 125.

Gallucci, G. O., Hamilton, A., Zhou, W., Buser, D. & Chen S. (2018) Implant placement and loading protocols in partially edentulous patients: A systematic review. *Clinical Oral Implants Research* **29 Suppl**: 106 - 134.

Gallucci, G. O., Mavropoulos, A., Bernard, J. P. & Belser, U. C. (2007) Influence of immediate implant loading on peri-implant soft tissue morphology in the edentulous maxilla. *International Journal of Oral & Maxillofacial Implants* **22**: 595 - 602.

Gallucci, G. O., Evans, C., Tahmaseb, A., Wismeijer, D., Barter, S. & Donos, N. (2019) ITI Treatment Guide. Volume 11, Digital Workflows in Implant Dentistry, Berlin: Quintessence Publishing.

Gintaute, A., Weber, K., Zitzmann, N. U., Bragger, U., Ferrari, M. & Joda, T. (2021) A Double-Blind Crossover RCT Analyzing Technical and Clinical Performance of Monolithic ZrO2 Implant Fixed Dental Prostheses (iFDP) in Three Different Digital Workflows. *Journal of Clinical Medicine* **10**.

González-Martín, O., Lee, E., Weisgold, A., Veltri, M. & Su, H. (2020) Contour Management of Implant Restorations for Optimal Emergence Profiles: Guidelines for Immediate and Delayed Provisional Restorations. *International Journal of Periodontics & Restorative Dentistry* **40**: 61 - 70.

González-Martín, O., Solano-Hernandez, B., González-Martín, A. & Avila-Ortiz, G. (2020) Orthodontic Extrusion: Guidelines for Contemporary Clinical Practice. *International Journal of Periodontics & Restorative Dentistry* **40**: 667-676.

Grunder, U., Gracis, S. & Capelli, M.(2005) Influence of the 3-D bone-to- implant relationship on esthetics. *International Journal of Periodontics & Restorative Dentistry* **25**: 113 - 119.

Hassan, B., Greven, M. & Wismeijer, D. (2017) Integrating 3D facial scanning in a digital workflow to CAD/CAM design and fabricate complete dentures for immediate total mouth rehabilitation. *Journal of Advanced Prosthodontics* **9**: 381 - 386.

Higginbottom, F., Belser, U., Jones, J. D. & Keith, S. E. (2004) Prosthetic management of implants in the esthetic zone. *International Journal of Oral & Maxillofacial Implants* **19 Suppl**: 62 - 72.

Joda, T., Ferrari, M. & Braegger, U. (2016) A digital approach for one-step formation of the supra-implant emergence profile with an individualized CAD/CAM healing abutment. *Journal of Prosthodontic Research* **60**: 220 - 223.

Joda, T., Wittneben, J. G. & Brägger, U. (2014) Digital implant impressions with the "Individualized Scanbody Technique" for emergence profile support. *Clinical Oral Implants Research* **25**: 395 - 397.

Jung, R. E., Holderegger, C., Sailer, I., Khraisat, A., Suter, A. & Hammerle, C. H. (2008) The effect of all-ceramic and porcelain-fused-to-metal restorations on marginal peri-implant soft tissue color: a randomized controlled clinical trial. *International Journal of Periodontics & Restorative Dent*istry **28**: 357-365.

Kan, J. Y., Rungcharassaeng, K., Umezu, K. & Kois, J. C. (2003) Dimensions of peri-implant mucosa: an evaluation of maxillary anterior single implants in humans. *Journal of Periodontology* **74**: 557 - 562.

Kurbad, A. & Kurbad, S. (2013) CAD/CAM-based implant abutments. *International Journal of Computerized Dentistry* **16**: 125 - 141.

Linkevicius, T. & Vaitelis, J. (2015) The effect of zirconia or titanium as abutment material on soft peri-implant tissues: a systematic review and meta-analysis. *Clinical Oral Implants Research* **26 Suppl 11**: 139 - 147.

Linkevicius, T., Linkevicius, R., Alkimavicius, J., Linkeviciene, L., Andrijauskas, P. & Puisys, A. (2018) Influence of titanium base, lithium disilicate restoration and vertical soft tissue thickness on bone stability around triangular-shaped implants: A prospective clinical trial, *Clinical Oral Implants Research* **29**: 716 - 724.

Linkevicius, T., Puisys, A., Steigmann, M., Vindasiute, E. & Linkeviciene, L. (2015) Influence of Vertical Soft Tissue Thickness on Crestal Bone Changes Around Implants with Platform Switching: A Comparative Clinical Study. *Clinical Oral Implants Research* **17**: 1228 - 1236.

Lops, D., Stellini, E., Sbricoli, L., Cea, N., Romeo, E. & Bressan E. (2017) Influence of abutment material on peri-implant soft tissues in anterior areas with thin gingival biotype: a multicentric prospective study. *Clinical Oral Implants Researc*h **28**: 1263 - 1268.

Marei, H.F., Abdel-Hady. A., Al-Khalifa, K. & Al-Mahalawy, H. (2019) Influence of surgeon experience on the accuracy of implant placement via a partially computer-guided surgical protocol. *International Journal of Oral & Maxillofacial* Implants **34**: 1177 - 1183.

Martin, W. C., Pollini, A. & Morton, D. (2014) The influence of restorative procedures on esthetic outcomes in implant dentistry: a systematic review. *International Journal of Oral & Maxillofacial Implants* **29 Suppl**: 142 - 154.

Monaco, C., Evangelisti, E., Scotti, R., Mignani, G. & Zucchelli, G. (2016) A fully digital approach to replicate peri-implant soft tissue contours and emergence profile in the esthetic zone. *Clinical Oral Implants Research* **27**: 1511 - 1514.

Monje, A., Chappuis, V., Monje, F., Muñoz, F., Wang, H. L., Urban, I. A & Buser, D. (2019) The Critical Peri-implant Buccal Bone Wall Thickness Revisited: An Experimental Study in the Beagle Dog. *International Journal of Oral & Maxillofacial Implants* **34**: 1328 - 1336.

Morton, D., Chen, S. T., Martin, W. C., Levine, R. A. & Buser, D. (2014) Consensus statements and recommended clinical procedures regarding optimizing esthetic outcomes in implant dentistry. *International Journal of Oral & Maxillofacial Implants* **29 Suppl**: 216 - 220.

Morton, D., Gallucci, G., Lin, W. S., Pjetursson, B., Polido, W., Roehling, S., Sailer, I., Aghaloo, T., Albera, H., Bohner, L., Braut, V., Buser, D., Chen, S., Dawson, A., Eckert, S., Gahlert, M., Hamilton, A., Jaffin, R., Jarry, C., Karayazgan, B., Laine, J., Martin, W., Rahman, L., Schlege, A. l, Shiota, M., Stilwell, C., Vorster, C., Zembic, A. & Zhou, W. (2018) Group 2 ITI Consensus Report: Prosthodontics and implant dentistry. *Clinical Oral Implants Research* **29 Suppl 16**: 215 - 223.

Ntounis, A., Pitman, L. M., Pollini, A., Vidal, R., Lin, W. S., Madigan, M. P. & Greenwell, H. (2015) The ABC Protocol in the Esthetic Zone: A Comprehensive Surgical and Prosthetic Approach. *International Journal of Periodontics & Restorative Dentistry* **35**: 561 - 569.

Palacci, P. & Nowzari, H. (2008) Soft tissue enhancement around dental implants. *Periodontology 2000* **47**: 113 - 132.

Papaspyridakos, P., Chen, C. J., Singh, M., Weber, H. P. & Gallucci, G. O. (2012) Success criteria in implant dentistry: A systematic review. *Journal of Dental Research* **91**: 242 - 248.

Papaspyridakos, P., Mariano, A., De Souza, A., Kotina, E., Kudara, Y. & Kang, K. (2020) Digital Workflow With a Triple Scanning Technique for Implant Rehabilitation in the Esthetic Zone. *Compendium of Continuing Education in Dentistry* **41**: e5 - e9.

Pjetursson, B. E., Sailer, I., Latyshev, A., Rabel, K., Kohal, R. J. & Karasan, D. (2021) A systematic review and meta-analysis evaluating the survival, the failure, and the complication rates of veneered and monolithic all-ceramic implant-supported single crowns. *Clinical Oral Implants Research* **32 Suppl 21**: 254 - 288.

Pjetursson, B. E., Sailer, I., Makarov, N. A., Zwahlen, M. & Thoma, D. S. (2017) Corrigendum to "All-ceramic or metal-ceramic tooth-supported fixed dental prostheses (FDPs)? A systematic review of the survival and complication rates. Part II: Multiple-unit FDPs" [Dental Materials 31 (6) (2015) 624-639]. *Dental Materials* **33**: e48 - e51.

Pjetursson, B. E., Valente, N. A., Strasding, M., Zwahlen, M., Liu, S. & Sailer, I. (2018) A systematic review of the survival and complication rates of zirconia-ceramic and metal-ceramic single crowns. *Clinical Oral Implants Research* **29 Suppl 16**: 199 - 214.

Roccuzzo, M., Roccuzzo, A. & Ramanuskaite A. (2018) Papilla height in relation to the distance between bone crest and interproximal contact point at single-tooth implants: A systematic review. *Clinical Oral Implants Research* **29** Suppl 15: 50 - 61.

Romandini, M., Pedrinaci, I., Lima, C., Soldini, M. C., Araoz, A. & Sanz, M. (2021) Prevalence and risk/protective indicators of buccal soft tissue dehiscence around dental implants. *Journal of Clinical Periodontology* **48**: 455 - 463.

Sadowsky, S. J. 2020. Has zirconia made a material difference in implant prosthodontics? A review. *Dental Materials* **36**: 1 - 8.

Sailer, I., Muhlemann, S., Zwahlen, M., Hammerle, C. H. & Schneider, D. (2012) Cemented and screw-retained implant reconstructions: a systematic review of the survival and complication rates. *Clinical Oral Implants Research* **23 Suppl 6**: 163 - 201.

Sailer, I., Philipp, A., Zembic, A., Pjetursson, B. E., Hämmerle, C. H. & Zwahlen, M. (2009) A systematic review of the performance of ceramic and metal implant abutments supporting fixed implant reconstructions. *Clinical Oral Implants Research* **20 Suppl 4**: 4 - 31.

Sailer, I., Pjetursson, B. E., Zwahlen, M. & Hammerle, C. H. (2007) A systematic review of the survival and complication rates of all-ceramic and metal-ceramic reconstructions after an observation period of at least 3 years. Part II: Fixed dental prostheses. *Clinical Oral Implants Research* **18 Suppl 3**: 86 - 96.

Sailer, I., Strasding, M., Valente, N. A., Zwahlen, M., Liu, S. & Pjetursson, B. E. (2018) A systematic review of the survival and complication rates of zirconia-ceramic and metal-ceramic multiple-unit fixed dental prostheses. *Clinical Oral Implants Research* **29 Suppl 16**: 184 - 198.

Salama, H. & Salama, M. (1993) The role of orthodontic extrusive remodeling in the enhancement of soft and hard tissue profiles prior to implant placement: a systematic approach to the management of extraction site defects. *International Journal of Periodontics and Restorative Dentistry* **13**: 312 – 333.

Salama, H., Salama, M., Garber, D. & Adar, P. (1998) The interproximal height of bone: a guidepost to predictable aesthetic strategies and soft tissue contours in anterior tooth replacement. *Practical Periodontics & Aesthetic Dentistry* **10**: 1131 – 1141.

Sanz-Martín, I., Regidor, E., Navarro, J., Sanz-Sánchez, I., Sanz, M. & Ortiz-Vigón, A. (2000) Factors associated with the presence of peri-implant buccal soft tissue dehiscences: A case-

control study. *Journal of Periodontology* Epub ahead of print.

Sanz-Sánchez, I,, Ortiz-Vigón, A., Sanz-Martín, I., Figuero, E. & Sanz, M. (2015) Effectiveness of Lateral Bone Augmentation on the Alveolar Crest Dimension: A Systematic Review and Meta-analysis. *Journal of Dental Research* **94 Suppl**: 128S - 142S.

Sanz, M., Lindhe, J., Alcaraz, J., Sanz-Sanchez, I. & Cecchinato, D. (2017) The effect of placing a bone replacement graft in the gap at immediately placed implants: a randomized clinical trial. *Clinical Oral Implants Research* **28**: 902 - 910.

Siebert, C., Rieder, D., Eggert, J., Wichmann, M. G. & Heckmann, S. M. (2018) Long-Term Esthetic Outcome of Tissue-Level and Bone-Level Implants in the Anterior Maxilla. *International Journal of Oral & Maxillofacial Implants* **33**: 905 - 912.

Souza, A. B., Alshihri, A., Kämmerer, P. W., Araújo, M. G. & Gallucci, G. O. (2018) Histological and micro-CT analysis of peri-implant soft and hard tissue healing on implants with different healing abutments configurations. *Clinical Oral Implants Research* **29**: 1007 - 1015.

Spray, J.R., Black, C. G, Morris, H. F. & Ochi, S. (2000) The influence of bone thickness on facial marginal bone response: stage 1 placement through stage 2 uncovering. *Annals of Periodontology* **5**: 119 – 128.

Stefanini, M., Felice, P., Mazzotti, C., Mounssif, I., Marzadori, M. & Zucchelli, G. (2018) Esthetic evaluation and patient-centered outcomes in single-tooth implant rehabilitation in the esthetic area. *Periodontology 2000* **77**: 150 - 164.

Steigmann, M., Monje, A., Chan, H. L. & Wang H. L. (2014) Emergence profile design based on implant position in the esthetic zone. *International Journal of Periodontics & Restorative Dentistry* **34**: 559 - 563.

Stoupel, J., Lee, C. T., Glick, J., Sanz-Miralles, E., Chiuzan, C. & Papapanou, P. N.(2016) Immediate implant placement and provisionalization in the aesthetic zone using a flapless or a flap-involving approach: a randomized controlled trial. *Journal of Clinical Periodontology* **43**: 1171 - 1179.

Su, H., Gonzalez-Martin, O., Weisgold, A. & Lee, E. (2010) Considerations of implant abutment and crown contour: critical contour and subcritical contour. *International Journal of periodontics and Restorative Dentistry* **30**: 335 - 343.

Tarnow, D. P., Cho, S. C. & Wallace, S. S. (2000) The effect of inter-implant distance on the height of inter-implant bone crest. *Journal of Periodontology* **71**: 546 - 549.

Tarnow, D. P., Magner, A. W. & Fletcher, P. (1992) The effect of the distance from the contact point to the crest of bone on the presence or absence of the interproximal dental papilla. *Journal of Periodontology* **63**: 995 - 996.

Tavelli, L., Barootchi, S., Avila-Ortiz, G., Urban I. A., Giannobile, W. V. & Wang, H. L. (2021) Peri-implant soft tissue phenotype modification and its impact on peri-implant health: A systematic

review and network meta-analysis. *Journal of Periodontology* **92**: 21-44.

Totou, D., Naka, O., Mehta, S. B., & Banerji, S. (2021) Esthetic, mechanical, and biological outcomes of various implant abutments for single-tooth replacement in the anterior region: a systematic review of the literature. *International Journal of Implant Dent*istry **7**: 85.

Ueda, K., Güth, J. F., Erdelt, K., Stimmelmayr, M., Kappert, H. & Beuer, F. (2015) Light transmittance by a multi-coloured zirconia material. *Dental Materials Journal* **34**: 310 - 314.

Urban, I, A., Montero, E., Monje, A. & Sanz-Sánchez, I. (2019) Effectiveness of vertical ridge augmentation interventions: A systematic review and meta-analysis. *Journal of Clinical Periodontology* **46 Suppl**: 319 - 339

Vafiadis, D. (2008) Predictable implant abutment selection. *Practical Procedures and Aesthetic Sentistry* **20**: 224.

Vetromilla, B. M., Brondani, L. P., Pereira-Cenci, T. & Bergoli, C. D. (2019) Influence of different implant-abutment connection designs on the mechanical and biological behavior of single-tooth implants in the maxillary esthetic zone: A systematic review. *Journal of Prosthetic Dentistry* **121**: 398 - 403.e3.

Vignoletti, F. & Sanz, M. (2014) Immediate implants at fresh extraction sockets: from myth to reality. *Periodontology 2000* **66**: 132 - 152.

Wang, Y. M., Liu, X. & He, J. C. (2021) Clinical application of integrated angulated screw channel abutment crown in implant-supported rehabilitation of aesthetic area. *Hua Xi Kou Qiang Yi Xue Za Zhi* **39**: 712 - 717.

Wittneben, J. G., Buser, D., Belser, U. C. & Bragger, U. (2013) Peri-implant soft tissue conditioning with provisional restorations in the esthetic zone: the dynamic compression technique. *International Journal of Periodontics and Restorative Dentistry* **33**: 447 - 455.

Wittneben, J. G., Gavric, J., Belser, U. C., Bornstein, M. M., Joda, T., Chappuis, V., Sailer, I. & Bragger, U. (2017) Esthetic and Clinical Performance of Implant-Supported All-Ceramic Crowns Made with Prefabricated or CAD/CAM Zirconia Abutments: A Randomized, Multicenter Clinical Trial. *Journal of Dental Research* **96**: 163 - 170.

Zamzok, J. (1997) Nonsurgical soft tissue sculpting. *Alpha Omegan* **90**: 65 - 69.

Zarauz, C., Pitta, J., Pjetursson, B., Zwahlen, M., Pradies, G. & Sailer, I. (2021) Esthetic Outcomes of Implant-Supported Single Crowns Related to Abutment Type and Material: A Systematic Review. *International Journal of Prosthodontics* **34**: 229 - 249.

Zembic, A., Kim, S., Zwahlen, M. & Kelly, J. R. (2014) Systematic review of the survival rate and incidence of biologic, technical, and esthetic complications of single implant abutments supporting fixed prostheses. *International Journal of Oral & Maxillofacial Implants* **29 Suppl:** 99 - 116.