Implants in the Aesthetic Zone

A Guide for Treatment of the Partially Edentulous Patient

Todd R. Schoenbaum
Editor

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I would like to thank my amazing wife Amy for her support and patience during this project. Through her, and with her, all things are possible. I would also like to extend my deepest gratitude to the amazing scientists, clinicians, and technicians who contributed to this book. They were selected because they are unsurpassed in their expertise in the profession. I am forever in their debt. Lastly, I would like to thank you, the reader, for taking the time to read this text. It is my sincere hope that it contributes to you, your practice, and your patients.

Foreword

Aesthetics is commensurate with health and well-being, and this is no more true than when considering teeth and oral health. The absence of teeth, through trauma, disease, or genetic disturbance, is considered by many patients a form of disability. With the advent of dental implants, we, the dental profession, have the means of resolving these issues and improving the quality of life for our patients.

Dr. Todd Schoenbaum has succeeded in bringing together some of the master scholars within the field of implant dentistry, both surgeons and restorative clinicians. The contributors to this text come from all over the world; all have unique abilities that lie not only in treating patients in their clinics, but also the desire to pass on their knowledge and expertise. The intention is to provide the reader with a foundation to further expand their own capabilities and ultimately improve the treatment of those under our care.

Chandur P. K. Wadhwani

Preface

This text is intended to serve as a clinical guide for treatment of implants in the aesthetic zone. This area and treatment modality is uniquely complex in dentistry, requiring skill and expertise from surgeons, restorative clinicians, and technicians. Success requires a team approach. Here you will see I have assembled an unmatched group of authorities from around the world to assist you in this process. Each brings their unique expertise and experience to their work here. You will find these experts are straightforward and generous with their knowledge.

I hope you enjoy reading this book as much as we did in creating it.

> Do you think that I count the days? There is only one day left, always starting over: it is given to us at dawn and taken away from us at dusk.—Sartre

Los Angeles, CA, USA — Todd R. Schoenbaum

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Part I

Treatment Planning for Implants in the Aesthetic Zone

1 Treatment Planning for Implants in the Aesthetic Zone: Biological, Functional, and Aesthetic Considerations

Peter K. Moy, Todd R. Schoenbaum, and Sam Alawie

Abstract

Proper interdisciplinary treatment planning is the cornerstone of implant treatment in the aesthetic zone. It requires diligent and thoughtful consideration of surgical, prosthetic, and technical aspects of the care to be provided. Though some cases will present similar challenges, no two are identical. Patients will be best served when the clinicians and technicians involved on the case understand the challenges faced by the other team members. Additionally, depending on the severity of the defect, patient expectations may need to be tempered to accept the clinical realities of their case. The "team approach" is key here. Each member should know and be able to predict what the others are going to be doing during their treatment stage. Often an immediate load approach will be attempted in the aesthetic zone. This requires high-level coordination, collaboration, and communication.

1.1 Importance of Treatment Planning

The success with any dental implant treatment starts with an accurate and appropriately sequenced treatment plan. Brånemark (Fig. 1.1) first introduced osseointegration as a multidisciplinary effort and would only permit clinicians to train as a team

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Fig. 1.1 Dr. P.I. Brånemark is the key innovator responsible for the modern approach to implant dentistry. His work in the field of osseointegration of titanium implants has revolutionized current dental treatment

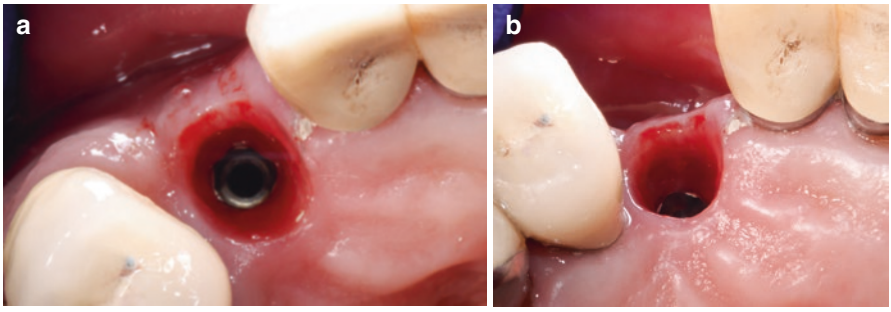

Fig. 1.2 (**a**, **b**) Peri-implant mucositis presents with various degrees of soft tissue pathologies, including inflammation, bleeding on probing, pus, fistula, and swelling

from both surgical and prosthodontic specialties. There are many factors to consider when treating the aesthetic zone with dental implants, even with a single missing tooth situation. Missing a single tooth in the aesthetic zone may often present as the most difficult and challenging to manage. The clinical assessment of the edentulous situation should be preceded by first identifying the cause of the edentulous state. If the cause for the loss of the tooth/teeth is not addressed first and corrected, once the implant is placed and has integrated, the alveolar defect that occurred and remains because of the tooth loss will lead to ongoing problems for the dental implant and implant-supported restoration. Ongoing problems such as inflammation of gingival tissues (better known as peri-implant mucositis) (Fig. 1.2a, b) leading to bone loss (peri-implantitis) (Fig. 1.3) will ultimately lead to the failure of the dental implant treatment. For example, if the tooth was lost due to trauma, there is often a concomitant loss of bone and/or soft tissues. If these deficiencies are present, an augmentation procedure or procedures should be performed first to restore lost tissues before placement of the dental implant. When the treatment is for the aesthetic zone, the best results occur when the alveolar ridges are ideally reconstructed to original contours and volume. This permits the ideal positioning of the implant during placement to best support the restoration. If the tooth was lost due to periodontal disease, not only must one worry about reconstructing lost hard and soft tissues but the periodontal status of the adjacent teeth and its effect on planned dental implant

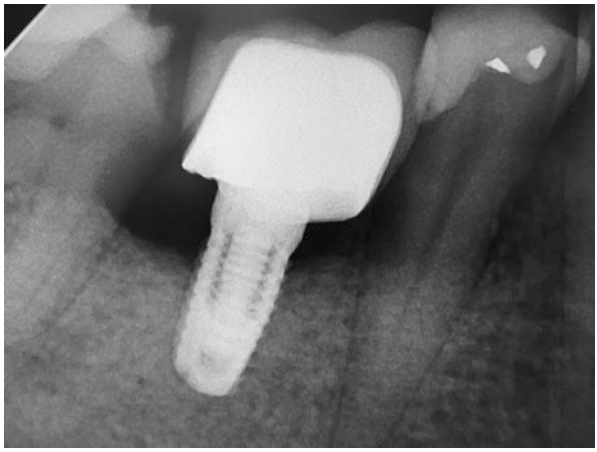

Fig. 1.3 Peri-implantitis is usually the result of untreated peri-implant mucositis. This results in a progression to atypical and aggressive bone loss around the implant. It may result in loss of the implant if unresolved

treatment must be accounted for. In a paper by Sgolastra et al. [1] using a systematic review of longitudinal prospective studies only, the authors identified strong evidence and with statistical significance that periodontitis is a risk factor for implant loss, moderate evidence and with statistical significance for periodontitis as a risk factor for peri-implantitis, and moderate evidence but not statistically significant for patients exhibiting periodontitis to experience greater peri-implant bone loss. For the aesthetic zone, the long-term outcome of implant treatment and maintenance of hard and soft tissue volume is extremely important in determining whether treatment was successful or not. A prosthetically driven, interdisciplinary, and systematic approach must be used if aesthetic risk factors are identified and managed accordingly [2].

1.2 Systematic and Interdisciplinary Approach

1.2.1 Medical Assessment

The implant patient's medical conditions will often affect the clinical outcomes of dental implant treatment, and the surgical specialist must be aware of these conditions so that preventative and/or corrective measures may be instituted to provide the implant patient with the best outcome. Several medical conditions are known to have negative effects on clinical outcomes with dental implant treatment [3]. Conditions such as diabetes, long-term steroid use, radiation therapy for oral-facial cancer, postmenopausal hormonal replacement therapy, and social habit (smoking) are associated with higher dental implant failure rates. The failures are due to delayed or poor healing of soft tissues typically related to poor vascularity resulting in exposure of the implant and surrounding bone structures. The 2005 article noted that although these medically related conditions present as relative contraindications for dental implant therapy, the overall failure rate of dental implants are low,

and there are no absolute contraindications to implant placement. However, the medical conditions that present with increased risk for failure should be considered during treatment planning phase and included in the informed consent process. The implant patient with identified medical conditions that affect healing processes of hard and soft tissues must be made aware that their medical conditions should be stable or corrected prior to initiating implant treatment.

1.2.2 Dental Assessment

The dental assessment should include evaluation of the remaining dentition, how maintainable are the restorations, the periodontal status, and the volume of hard and soft tissues in the edentulous site and adjacent tooth structures. It is especially important to assess the dentition adjacent to the implant site. Residual infections from previous periapical abscess, periodontal disease, and/or soft tissue conditions where recession has exposed roots of adjacent teeth must be corrected.

1.2.3 Psychological (Patient MOTIVATION) Assessment

When the clinician is dealing with the aesthetic zone, the patient's expectations for treatment outcome must be understood. Once the clinician understands the patient's expectation, it is imperative that the clinician educate the patient on anticipated results and requirements for maintenance. Walia and coworkers [4] determined that a patient's seeking implant treatment (motivation) and their expectations (satisfaction at conclusion of treatment) with implant treatment differ. Patients today are more aware of dental implants as a viable treatment to replace missing teeth, thanks to large volume of available information on social media. However, the patients are not aware of the complications associated with implant treatment for the aesthetic zone, specifically the lack of hard and soft tissue volume as well as contours. There are varying reports on what patients are actually looking for when seeking implant treatment. Rustemeyer and Brernerich [5] identified 68% of women and 41% of men in their study felt aesthetics to be very important with their treatment results. In another study [6], the systematic review found the high cost of implant treatment often resulted in unrealistic expectations of the implant patient. Even with these concerns, Pjeteursson et al. [7] found in their 10-year prospective study that 90% of the patients were completely satisfied with implant therapy, both from a functional and aesthetic standpoint. The use of dental implants to restore missing teeth in the aesthetic zone requires the treating clinician to have a thorough understanding of what motivates the patient and what their expectations are at the completion of treatment. The potential for poor aesthetic results due to loss of interproximal papilla or hard tissue contours must be explained to the patient and the likelihood of this risk occurring. Included in the discussion is the need to surgically correct the deficiencies prior to implant placement.

1.3 Restorative Considerations for Treatment Planning Implants in the Aesthetic Zone

Our three primary concerns restoratively are functional, biological, and aesthetic (Table 1.1).

1.3.1 Functional Concerns

We must understand the risks of abutment failure, crown or FDP (fixed dental prosthesis; aka "bridge") failure, and screw breakage/loosening. Titanium and cast alloy abutments will have the least risk of breakage. The primary disadvantage of metal abutments in the aesthetic zone is discoloration of the soft tissues. Full contour zirconia abutments will generally have the highest risk of breakage (Fig 1.4a, b). The zirconia abutment luted to a "Ti Base" seems promising

Table 1.1 Restorative considerations for implants in the aesthetic zone

Functional concerns	Biological concerns	Aesthetic concerns
Abutment fracture	Risk of retained cement	Discoloration of the gingiva
Crown fracture	Reactions to metal alloys	Shade match for the crown
Screw fracture	Loose screws	Margin reveal
Screw loosening	Gingival recession	Gingival recession
	Poor fitting components	Screw access showing
	Porosities in the metal or ceramic materials	

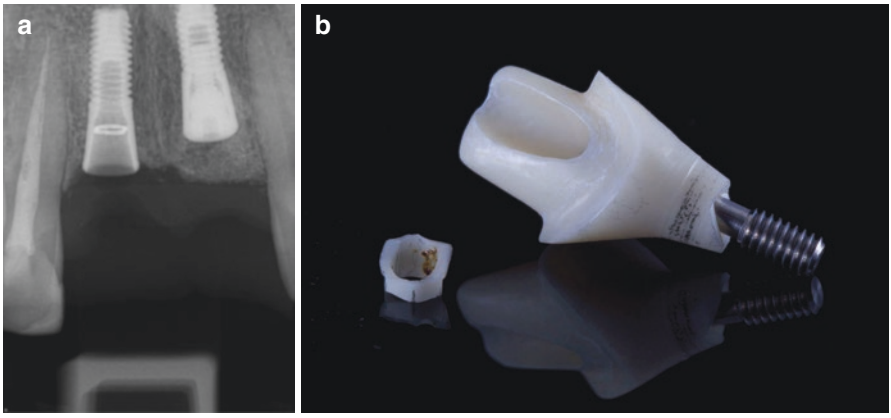

Fig. 1.4 (**a**, **b**) A full zirconia abutment has fractured inside the implant connection. The use of abutments without a Ti Base is risky due to this potential complication. The apical portion of the fractured zirconia abutment is visible on the radiograph as a radiopaque ring. Such fractures can be difficult to treat, as the remaining zirconia portion may be wedged in place requiring drilling to remove (courtesy of Dr. David Wagner)

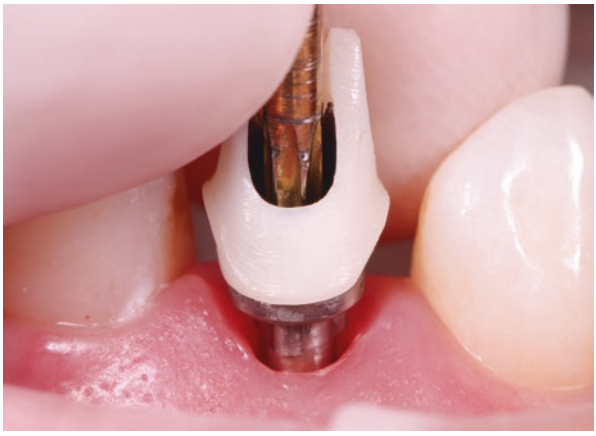

Fig. 1.5 When zirconia abutments are indicated (generally due to high smile line and thin gingival biotype), they should be fabricated with a Ti Base. This helps to increase strength and minimize the challenges of retreatment should the abutment break

(Fig. 1.5). At the current time, there has only been one study looking at the strength of the Zr/Ti Base abutments [8]. This design appears to decrease the risk of breakage during cyclic loading; however, this is dependent on the implant being used, the Ti Base, the cementation protocol, the thickness of the zirconia, and the lab used to manufacture them. The take-home point being that not all Zr/Ti abutments are created equal. There are also an increasing amount of anecdotal reports of the zirconia abutment debonding from the Ti Base. While obviously problematic, this is relatively easy to resolve by re-bonding. The laboratory technician must ensure that the cementation protocols are properly followed and that the Ti Base is as long as possible. Far too many of these restorations seem to have insufficient height of the Ti Base.

An additional advantage of the Zr/Ti abutment is that, should the zirconia break, retrieval and removal is simple and predictable. This is in stark contrast to the failure of full zirconia abutments, which usually occurs at the neck of the implant connection. This leaves a small ring of zirconia inside the implant, which can be difficult to remove, especially in some tapered connections. The remaining Zr piece may have to be drilled out if it cannot be pulled out. This can cause significant damage to the connection interface in the implant. As such, full contour Zr abutments (without the Ti Base) should be avoided.

For the crowns on implants in the aesthetic zone, most of the modern ceramic materials appear to be strong enough. However, for scenarios requiring an FDP with a pontic, the lithium disilicate materials are generally best avoided due to an increased possibility of fracture at the connector. PFM (porcelain fused to metal) or PFZ (porcelain fused to zirconia) would be preferable options.

Loose and broken screws (Fig. 1.6) used to be a common occurrence and frustration. Improved alloys (i.e., Ti alloys replacing Au alloys), widespread use of torque wrenches (Fig. 1.7), and improved coatings on the screws have decreased the incidence of loosening somewhat. However, the great reduction in loosening and breakage is due to improved implant—abutment connections. The early root form implants with an external hex were not designed to retain single-unit prostheses. In

Fig. 1.6 Even modern titanium screws can fracture if they are improperly treated. Special care must be taken to ensure passive fit of the abutment and to not surpass the manufacturer torque values. The screw here was broken at delivery leaving the small threaded remnant to be carefully retrieved from inside the implant

Fig. 1.7 The use of a torque wrench is essential for delivery of implant restorations. They help the clinician ensure that the screw creates the proper pre-load without fatiguing the screw or implant. Most (but not all) screws are designed to be torqued to 30–35 Ncm

fact, the external hex was primarily designed to interface with the available drivers, and retaining a prosthesis was its secondary job. The external hex is generally less than 1 mm in height. This provides very little resistance and retention, placing all the off-angle force vectors on the screw, thus resulting in screws coming loose or breaking over time. So much so that it is generally advisable that all external hex implants be restored with a screw-retained restoration to allow for ease of screw replacement and re-torqueing.

There are hundreds of variants of internal connections currently available. Although they vary greatly in their engineering, as a general rule, they have a much more intimate and robust connection. This results in significant reductions in screw loosening. Some of these connections are so well designed that abutments can be difficult to remove even after the screw has been taken out. For restoring implants in the aesthetic zone, internal connection implants should be used. Additionally, most (but not all) data [9–12] show that a platform switch design will aid in maintaining peri-implant bone and soft tissue levels.

Occlusal management of implants in the aesthetic zone is critical to long-term success. Dr. Stevenson covers this topic in depth in Chap. 18.

1.3.2 Biological Concerns

First and foremost, the restoration selected/designed should impose a minimal risk in inducing peri-implantitis or peri-implant mucositis. Residual cement on the abutment is the most frequently discussed cause of peri-implantitis. While this is undeniably true, implementation of some relatively common sense guidelines mitigate this risk. Chief among these guidelines is that all abutments for cemented restorations should be custom milled, such that the margins are clearly accessible (Fig. 1.8) when the crown/prosthesis is cemented. See Chap. 14 for more information on the proper use of cemented restorations. It is important for the restoring dentist to understand the low-risk cementation protocols, because it is inevitable that patients will present with implants that do not allow for a traditional screw-retained restoration (Fig. 1.9a, b). The use of lingual set screws may serve as an alternative solution

Fig. 1.8 Margin placement is the crucial factor for using cemented implant restorations with minimal risk of retained cement and peri-implantitis. Here the Zr/Ti Base abutment was prescribed to have margin at −0.5 mm on the distal, facial, and mesial and at 0 mm on the palatal. This ensures easy access for cement removal and evaluation with little risk of aesthetic concerns

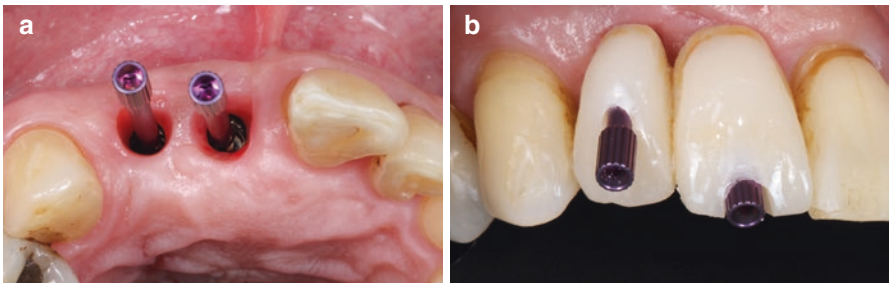

Fig. 1.9 (**a**, **b**) Unfortunately, not all implants are placed with access through the palatal, and not all manufacturers offer an angled screw channel option. Such cases are difficult to manage without a proper understanding of how to cement the restoration without the risk of retained cement on the abutment surface

to facially angled implants, but they are difficult to fabricate and have little to no evidence supporting their use. It should be well noted though that proper planning and surgical/restorative coordination *prior* to implant placement will minimize the frequency of such occurrences.

Additional prosthetic causes of peri-implantitis/mucositis include reactions to metal alloys, loose screws, poor fitting restorations and casted abutments (Fig. 1.10), poor fitting third party components, and porosities in the metal or ceramic materials. If left unresolved, peri-implant mucositis will lead to atypical bone loss around the implant.

The other area in which the restorative clinician affects the peri-implant biology is in the realm of abutment emergence profiles. The shape of the abutment where it joins the implant and as it emerges through the soft tissue will have significant effect on the health, cleansibility, and aesthetics of the peri-implant soft tissues. See Chap. 13 for more information on the design and effects of the abutment emergence profile.

Abutment cleanliness is also critical for the restorative clinician and technician to address prior to delivery of the prostheses. Most abutments and crowns regardless of design come out of the lab with significant amounts of particulate debris on their

Fig. 1.10 Poorly designed abutments and poor fitting restorations allow for bacterial reservoirs that induce peri-implantitis. Here the margins of the crowns have a significant marginal gap unfilled by cement. Thus allowing plaque and bacterial to accumulate, ultimately resulting in loss of the implants

surface. Canullo et al. recently published a survey [13] on how and if clinicians clean and disinfect prosthetic implant components. Worldwide there is huge variation in how this is done (steam, chlorhexidine, autoclave), and for the most part, the components are being placed into surgical implant sites without sufficient cleanliness. Even when cleaned as described above, the components still retain a significant amount of particulate debris. Preliminary studies have shown that proper cleaning of the abutments (with plasma of Argon) prior to placement can significantly increase the levels of retained bone around the implant. At a bare minimum, implant abutments and prostheses should be thoroughly steam cleaned and disinfected.

1.3.3 Aesthetic Considerations

The restorative aesthetic considerations for implants in the aesthetic zone are soft tissue color, soft tissue contour, and crown/prosthesis shade. The various studies examining the effects of abutment material on the perceived color of the soft tissues have failed to reach uniform conclusions. Most show that silver-colored metals (i.e., gold alloys, titanium) produce the greatest amount of discoloration of the gingiva, while ceramic-type materials (i.e., zirconia, lithium disilicate, alumina) produce the least color shift (Fig. 1.11). Of course with the use of ceramic-type abutment materials comes an increased risk of fracture not present with metals. As described in the *functional considerations* section above, the zirconia abutments should have a Ti Base design. This *functional risk* must be weighed against the aesthetic demands of the case. As an intermediary material, anodized or coated titanium (pink or gold colors) (Fig. 1.12) produce less graying of the soft tissue than the uncoated metals. This process can be performed by the manufacturer, the laboratory, or in the clinician's office. Wadhwani et al. [14] have described the DIY anodization process in detail. Soft tissue thickness is also a key component to creating or maintaining natural soft tissue color. If gray tissue is present around an implant, the two possible solutions are increasing soft tissue thickness with a graft or replacing the abutment with one of the more aesthetic materials mentioned above.

Challenging cases with high *functional risks* and high *aesthetic demands* require carefully selected solutions that mitigate the potential for failure. When proper

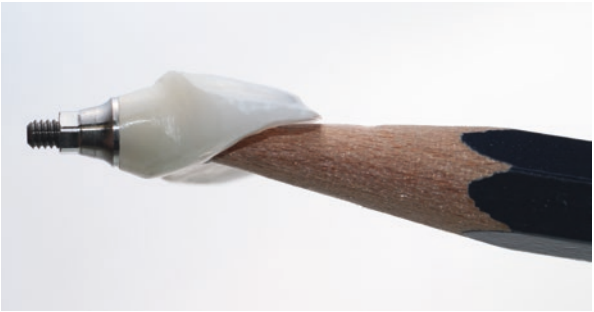

Fig. 1.11 The zirconia framework with Ti Base is an appropriate restoration design for the aesthetic zone with thin tissue biotypes and high smile lines. Here a screw-retained design was utilized

Fig. 1.12 Minor—moderate tissue discoloration can also be mitigated with the anodization of Ti abutments. Here a provisional abutment has to be anodized to have a pink hue in the emergence area and a gold hue in the crown area. This procedure can be easily accomplished in the office with simple materials (see [14])

planning and coordination has been performed prior to starting the treatment, implant selection and orientation can be determined prior to surgery to allow for management of these challenges. For the single-tooth implant in the aesthetic zone, the screw-retained zirconia/Ti Base crown + abutment may prove to be an ideal solution if the implant is able to be placed in an ideal position. See Chap. 15 for Linkevicius and Puisys' excellent review of this treatment option. It needs to be understood though that this restoration requires an attentive technician to ensure that the abutment is as long as possible and it is properly cemented.

Management of the soft tissue around the implant requires interdisciplinary coordination. The surgeon is responsible for creating/maintaining sufficient bone in which to place the implant(s), but also enough bone to properly support the peri-implant tissues. Patient factors (i.e., smoking, diabetes) will also affect the quantity and quality of the bone available. When bone is lost on the roots adjacent to the implant site, it can be very difficult to restore the bone to ideal positions. Soft tissues will generally represent the underlying bone architecture, although grafting procedures may be successful in masking bony defects with increased soft tissue thickness. Thicker soft tissue is less prone to atypical recession and remodeling, thus ensuring better long-term peri-implant aesthetics.

The restoring clinician is responsible for fine-tuning the contours of the soft tissues through the conscientious use of provisional restorations (Fig. 1.13a, b). The final form and position of the soft tissues can be moved (within a range) by changes in the shape of the provisional restoration. Generally, over-contouring of the emergence or pontic will move tissues apically, while flat or under-contoured shapes will allow tissue to move coronally. There are limitations and variables that will affect how much the tissues can be manipulated by the provisional restorations. As a general rule, the soft tissue architecture should be refined in the provisional stage, before making the definitive impression. It is much easier to perform additional surgeries or modify the prostheses in the provisional stage than it is to correct deficiencies after the definitive restoration has been delivered. See Chaps. 10 and 13 for

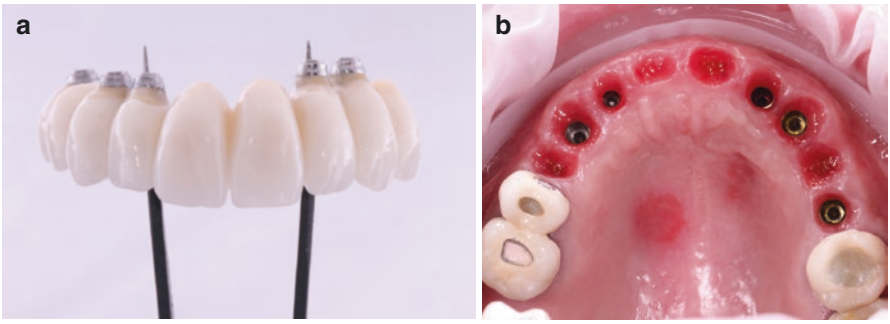

Fig. 1.13 The provisional restoration (**a**) has to be carefully designed with ovate pontics and narrow emergence around the implants in order to shape the soft tissues. (**b**) The tissue contours after 3 months of the provisional in place

more details on the process of fabricating provisional restorations and using them to modify the positions of the soft tissue.

1.4 Surgical Considerations for Treatment Planning Implants in the Aesthetic Zone

The surgical considerations to take into account during the treatment planning by the surgical specialist should mimic that of the restorative concerns and requirements of the restoration in order to provide the best surgical outcomes to support the planned restoration. Therefore, the restorative plan (type of implant restoration, emergence contours, and interproximal contacts) must be known. Otherwise, the surgeon will end up placing the implant where the best available bone dictates it to go rather than the implant restoration dictating the ideal implant position. The surgeon must know specific information concerning the restoration in order to place the implant in the ideal position. This includes the contours of the restoration, the emergence contours, the location of the central fossa, and the method of crown to implant connection.

1.5 Functional Concerns

1.5.1 Occlusion

Implants are designed to withstand heavy occlusal forces vertically. When there are excessive lateral forces, the distribution of forces is limited resulting in bone loss surrounding the implant (Fig. 1.14). Thus, the patient who exhibits grinding habits or bruxism must be placed into a night guard to compensate for the unnatural lateral movement of the jaw, preventing the excessive lateral forces and the excessive bone loss that occurs around the dental implant.

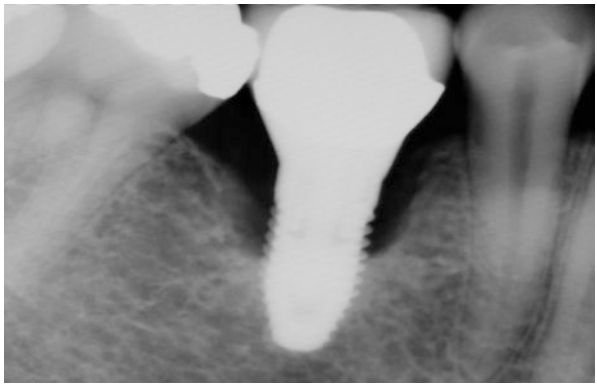

Fig. 1.14 Atypical bone loss around a posterior implant is illustrated in this radiograph. In the absence of any obvious factors, excessive occlusion should be considered as a possible etiology

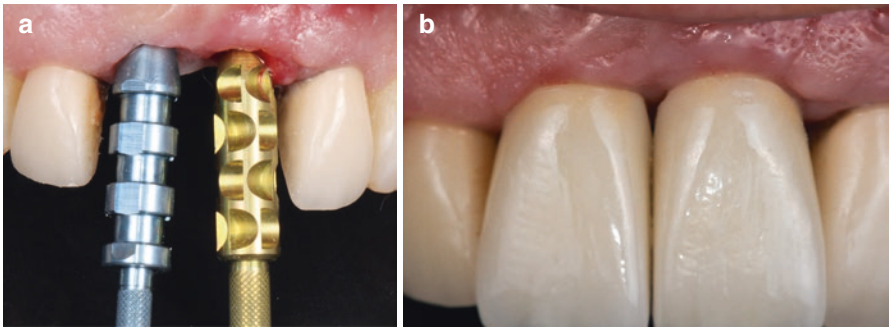

Fig. 1.15 (**a**, **b**) Special care must be used with adjacent implants in the aesthetic zone. These implants are slightly too close to each other and may have exacerbated the deficiency of the mesial papilla

1.5.2 One Versus Two Implants for Two-Teeth Edentulous Space

When the edentulous situation has two consecutively missing teeth, the length of the edentulous space is critical number to determine whether one or two implants will be used to replace the two missing teeth. This is especially critical in the incisor region.

1.5.3 Spacing of Implants

The spacing between implants will be a determining factor for the shape, contours, and volume of the papilla. If implants are too close to each other or to the adjacent tooth, there will be a loss of the papilla (Fig. 1.15a, b). When the implants are too far from each other or the adjacent tooth, the papilla contour flattens (Fig. 1.16a, b). In the posterior quadrant, when this happens food impaction becomes a chronic issue for the patient.

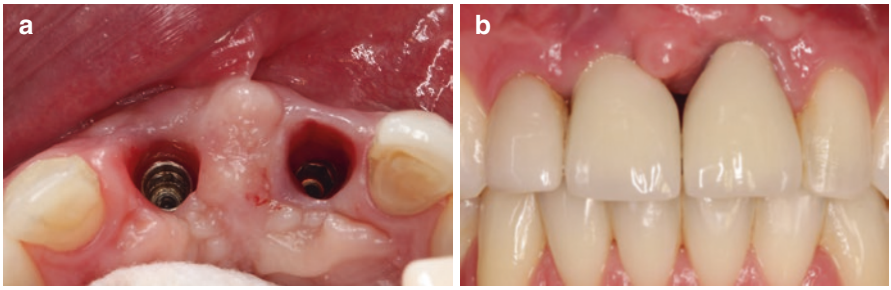

Fig. 1.16 At the other end of the spectrum, these implants (**a**, **b**) are placed too far apart, and this also makes creation of a reasonable papilla challenging at best

1.6 Biologic Concerns

1.6.1 Gingival Biotype [15, 16]

The thickness (real or perceived) of the peri-implant soft tissues should be considered prior to initiating implant treatment. Generally speaking, the thin tissue biotype must be carefully handled intraoperatively, and the use of anodized Ti or zirconia components will need to be considered. The thin biotype is also more susceptible to recession and appropriate remedies need to be planned for should this complication present.

1.6.2 Health of Periodontal Tissue

The periodontal status of the adjacent dentition will have a direct effect on the peri-implant soft tissue.

1.6.3 Future Health of Peri-implant Tissue

The maintenance of the peri-implant gingival tissue health is a concept implant patients must be educated on. The most common reason why the patient is missing a tooth or multiple teeth is due to periodontal disease. If the patient cannot maintain appropriate gingival health around natural dentition, they certainly will have problems maintaining gingival health around implants. This becomes more eminent as the patient ages and manual dexterity becomes an issue due to arthritic changes making it more difficult for the older patient to maintain hygiene around posterior implants. When the implant patient show signs of poor or inadequate oral hygiene home care, the conversion of the implant restoration from fixed to removable must be considered.

1.7 Aesthetic Concerns

1.7.1 Smile Line

The first inspection of the patient requiring an implant in the aesthetic zone is the smile line at rest or repose, half smile, and full smile. This assessment will help to

determine facial asymmetries, the amount of gingival show during movements, in full smile, half smile, and at rest. This assessment will help the surgeon determine the critical nature of maintaining tissue volume and contours. Patients with high smile lines should be approached with caution. Any loss of tissue contours or volume with the surgical procedure will be clearly visible resulting in an extremely dissatisfied patient.

1.7.2 UCLA Aesthetic Implant Analysis

This is a simple, inexpensive method to identify deficiencies, discrepancies, and asymmetries with the patient's dentition as well as deficiencies of hard and soft tissues. The analysis requires a clinical photograph of the patient's maxillary anterior dentition with lips retracted. The photograph should show back to the bicuspids with the midline centered in the photograph. (Fig. 1.17) There are three horizontal lines drawn. The superior line, *gingival margin line*, connects the zenith of the gingival margin of the canine to the contralateral canine. The middle line, *mesial papilla line*, connects the mesial papilla of the canine to the contralateral mesial papilla. The inferior line (incisal edge line) is a line drawn from the incisal tip of the canine to the contralateral canine tip. Once the three lines are drawn, any asymmetries, irregularities, and deficiencies are easily detected. This analysis serves as documentation for the clinician to review with the implant patient and to record the clinical condition pre- and posttreatment (Fig. 1.17 and 1.18).

1.7.3 Implant Positioning

In the past, the description of implant positioning has always been stated as three-dimensional (3-D). This concept was formulated due to limited capabilities of the diagnostic tools that were available in the late 1980s and early 1990s with plane film radiography as well as using a freehand surgical approach as a standard to placement of dental implants. The three dimensions or positions that surgeons are

Fig. 1.17 This is the UCLA Aesthetic Implant analysis in use. A, is the *gingival margin line* connecting the gingival zeniths of the canines. B, the *mesial papilla line* connects the papilla mesial to the canines. C, The *incisal edge line* connects the cusp tip of the canines. Here, the UCLA Aesthetic Implant analysis is used to quickly gauge for symmetry and proportion following implant placement and restoration of the left canine, with reasonable (but not perfect) results

accustomed to identify when placing an implant are *mesial-distal*, *buccal-lingual/palatal* angulation (Fig. 1.19), and *apical-coronal* (depth) positions (Fig. 1.20). The modern use of digital technology, specifically the cone beam computed tomography (CBCT) scan, permitted the clinician to observe three-dimensional reconstructed views of the patient's hard tissue. Today the clinician may view the hard tissue structures in the axial, coronal, and sagittal views thus enhancing the ability for the surgeon to place the implant in the ideal three-dimensional position. The introduction of software programs to assist in treatment planning introduced a fourth

Fig. 1.18 The pretreatment view of the patient in Fig. 1.17, illustrating a buccal alveolar concavity and significant disproportion of the teeth and soft tissues due to the retained primary left canine

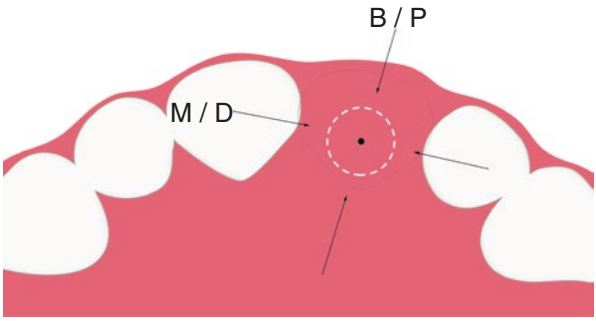

Fig. 1.19 The first two axes of the five-dimensional implant placement consideration. This figure represents both the mesial-distal and buccal-palatal position of the osteotomy

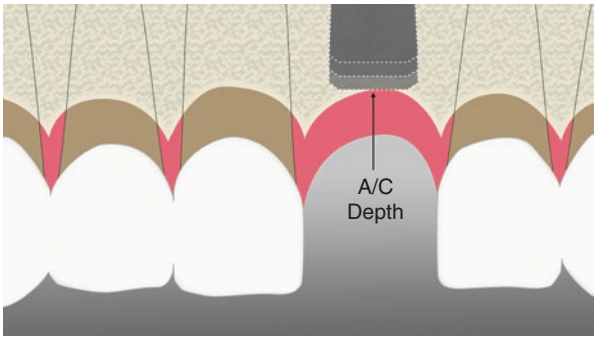

Fig. 1.20 The third axis is apical-coronal depth. This dimension is the depth to which the osteotomy is drilled and the implant placed relative to the planned gingival zenith

dimension to consider. This fourth dimension is known as "arch" position. Depending on the location of the implant in the arch and whether the arch is the maxilla or mandible, the tilt of the implant will differ. For example, an implant placed in the mandibular first molar position must be placed with the axis of the implant tilted slightly to the lingual. This differs from buccal-lingual angulation because accounting for this angulation is necessary to bring the access opening for a screw-retained restoration to come through the central fossa of the restoration. The arch position tilt accounts for the coronal shape of the restoration. The arch position assures the proper relationship of the working cusps of the maxillary and mandibular arches (Fig. 1.21). This fourth dimension becomes even more obvious when dealing with the fully edentulous arch. As the implant positions change from anterior to posterior in the mandible, the lingual tilt becomes more pronounced. If the surgeon attempt to place implants parallel to each other, the malposition of the posterior implants will be noticeable. As the surgical approaches for implant placement transitions from freehand to guided (CBCT planning programs) to navigation (dynamic guided), a fifth dimension became obvious. As the surgeon begins preparing the implant site using navigation approach, the focus is on placement of the drill tip on the cross hair image on the computer screen. Following this cross hair to depth represents the apical tip of the implant. Once the drill goes through the cortical layer on the crest of the ridge, the surgeon's focus is on the outer ring on the computer screen. This is seen as the angular deviation and represents the body of the implant and, ultimately, the neck of the implant located at the crest when the implant is completely seated (Fig. 1.22). This is called the "cone" position. The focus as the drilling preparation of the implant site proceeds, the surgeon attempts to keep the angular deviation as low as possible. Even with the deviation below one degree (1°), the neck position of the implant will have a variance that will change the access opening of the implant. As the technology and instrumentation improves, the surgeon must adapt to the use of the advancing technologies to ideally position the implants accounting for all five dimensions.

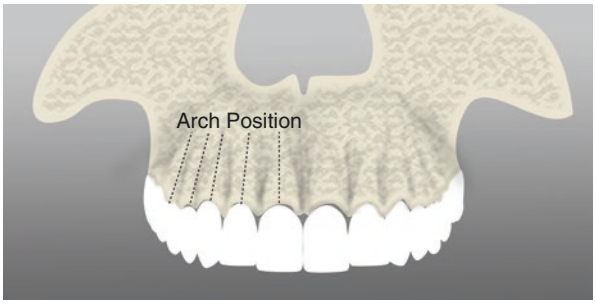

Fig. 1.21 The fourth axis is the *arch position*. This is to take into consideration the angulation of the jaw as we move around the arch. In the maxilla, it forms a somewhat cone shape, with the apical end of the implant being tipped palatally, while in the mandible it is generally the opposite due to the lingual concavity. Cross-sectional CBCT slices will aid the clinician in determining the appropriate angulation for the given patient

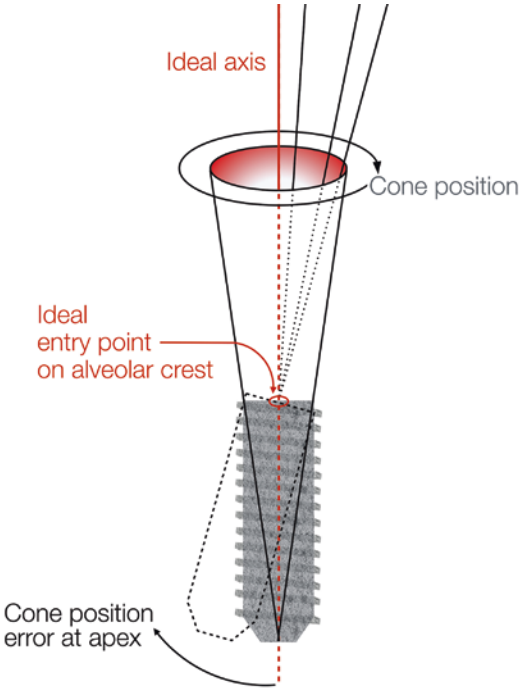

Fig. 1.22 The final axis is the *cone position*. This is to account for the rotational cone within which the surgeon is operating inside the guide or with the aid of navigation. Careful attention must be paid to this axis to ensure that the apical extent of the osteotomy/implant is properly positioned as well as having a significant effect on the exit of the screw channel within the prosthesis

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