Editors: A. Dawson, W. Martin, W. D. Polido

The SAC Classification in Implant Dentistry

SECOND EDITION

S STRAIGHTFORWARD A ADVANCED C COMPLEX

Authors:
A. Dawson
W. Martin
W. D. Polido

QUINTESSENCE PUBLISHING

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Foreword

The SAC Classification in Implant Dentistry

Almost 20 years ago, the International Team for Implantology – ITI – formalized the SAC classification to categorize oral implant treatment procedures into three levels of difficulty: Straightforward, Advanced, and Complex. *The SAC Classification in Implant Dentistry* was published in 2009, and it immediately became clear that this approach to classifying treatment risk when planning patient treatment was a tool many dentists had been waiting for. Applying the SAC approach to the evaluation of patient-related risk factors and treatment modifiers has since become a standard procedure for many practitioners, contributing to a higher degree of predictability in the execution and outcome of proposed treatment. The SAC classification has been recognized by dental professionals as an objective, evidence-based framework, also making it an invaluable educational tool for both predoctoral and postgraduate training programs.

As dental materials, technology, and clinical techniques have evolved in the intervening years, the ITI decided to review the SAC classification and present it to clinicians in an updated form: a digital book that can be accessed from any device or computer as needed. With its mission to promote and disseminate knowledge covering all aspects of implant dentistry and related tissue regeneration, the ITI recommends this SAC Assessment Tool to all professionals in the field.

Charlotte Stilwell
ITI President

Daniel Wismeijer
Chairman, ITI Education Committee

Acknowledgments

It may be trite, but it is true: projects such as this do not succeed without the commitment and hard work of a large team of people. Consequently, we would like to acknowledge the following people and groups.

The ITI Board of Directors trusted us to update one of the ITI's crown jewels – the SAC Classification. This is a heady responsibility, as we know that the SAC Classification is widely used and respected by clinicians in implant dentistry. We thank the Board for their trust and support.

The staff at the ITI Headquarters have supported us throughout the project. From the events team that organized our meetings, to the Communications and Education teams for providing material, all have worked cheerfully and willingly to help us. Of special note: many thanks to Kati Benthaus and Katalina Cano, our project managers, who have guided us through the process.

Thanks must go to Stefan Keller and his fellow IT wizards at FERN who have turned our dreams of what we would like to do with the online tool into reality.

Thanks also to Änne Kappeler and the team at Quintessence. Their professionalism and patience have allowed us to produce something that we can all be truly proud of.

Of course, we could not have done anything without the support of our colleagues on the Consensus Group who met in Zurich and Berlin and who toiled tirelessly to develop the framework for the new tool. Thanks also to the members of the ITI Education Committee and all the others who acted as our beta testers, and to those who have contributed material to this book. The quality of the group-achieved outcome is much, much more than the sum of the contributing parts.

And finally, but most importantly, we must thank our wives, children and families for their understanding and support. We could not have done this without you.

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CHAPTER 1:

Introduction to the Updated SAC Classification

A. DAWSON, W. MARTIN, W. D. POLIDO

1.1 Introduction

Implant dentistry is an integral part of modern dental practice, providing a strong evidence-based option for the rehabilitation of partially and completely edentulous patients. Clinical and technologic advancements in this field have increased the level of confidence that clinicians have in this form of therapy and have also led to a broader base of incorporation into daily practice. What was once the domain of specialist practice is now a common treatment modality in many, if not most, general practices. This has increased the need for all clinicians involved with the field of implant dentistry, irrespective of specialty, to be able to provide therapy at an appropriate level of care.

It has long been recognized that clinical situations present with different levels of difficulty and with different degrees of risk for esthetic, restorative, and surgical complications. Despite the advances in knowledge and improved techniques, implant dentistry is not free from risks of complications or suboptimal outcomes. Over the last decade, research in this field has increasingly provided information regarding the risks associated with this treatment option. The successful osseointegration of an implant is no longer the primary focus of treatment. Rather, the range of potential problems with implants and their related prostheses has come into sharper focus. It is in this environment that the SAC classification has evolved to assist practitioners in recognizing risk factors and providing appropriate levels of care.

1.2 Historical Background

The concept of assessing risk factors in implant dentistry has attracted considerable attention since the early 1990s, when the number of clinicians placing and restoring implants increased significantly. With this increase in use, the number of associated complications also increased.

Renouard and Rangert (1999) published a classification system that addressed the risk factors involved with the surgical and restorative phases of implant rehabilitation. At that time, they affirmed that some risk factors are relative, while others are absolute. The distinction between the two is not as clear as it might appear. However, several relative contraindications or one absolute contraindication should lead to a reevaluation of the original treatment plan. Although they were using terms like “OK,” “Caution,” and “Danger,” and using the green, yellow, and red colors associated with increased risk factors, an integrated decision tree was not present.

The term *SAC*, with the associated risk factor classification and color scheme, was first used by its two creators, Sailer and Pajarola (1999), in an atlas of oral surgery, with the intent to classify risk factors for general dentists practicing dentoalveolar surgery. The authors described in detail various clinical situations for procedures in oral surgery, such as the removal of third molars, and proposed the classification S = *Simple*, A = *Advanced*, and C = *Complex*. This concept was then adopted in 1999 by the Swiss Society of Oral Implantology (SSOI) during a 1-week congress on quality guidelines in dentistry. The working group of the SSOI developed this SAC classification from a surgical and prosthetic point of view for various clinical situations in implant dentistry. This SAC classification was then adopted by the International Team for Implantology (ITI) in 2003 during the ITI Consensus Conference in Gstaad, Switzerland. The surgical SAC classification was presented in the proceedings of this conference (Buser et al, 2004). The ITI Education Core Group decided in 2006 to slightly modify the original classification by changing the term *Simple* to *Straightforward*.

Fig 1. The participants of the SAC Consensus Conference held by the ITI in Palma de Mallorca in March 2007. (Source: The SAC Classification in Implant Dentistry, 2009).

In March 2007, the ITI held a consensus conference in Palma de Mallorca in Mallorca, Spain aimed at improving on the SAC classification (Figure 1). In its initial form, the SAC classification tended to be subjective, as it related the perceived difficulty of the treatment to the individual practitioner. The Mallorca meeting sought to develop a classification scheme that was more structured and objective. The results of this conference were published in an adjunct to the ITI Treatment Guide series in 2009 (Dawson & Chen, 2009). Later in 2009, the ITI developed an SAC Assessment Tool that clinicians could use to determine the normative classification for a case type that they were treating and identify any additional modifying factors that might apply to their own patient’s clinical situation.

The participants in the first SAC Conference were as follows: Urs Belser (Switzerland), Daniel Botticelli (Italy), Daniel Buser (Switzerland), Stephen Chen (Australia), Luca Cordaro (Italy), Anthony Dawson (Australia), Anthony Dickinson (Australia), Javier G. Fabrega (Spain), Andreas Feloutzis (Greece), Kerstin Fischer (Sweden), Christoph Hämmerle (Switzerland), Timothy Head (Canada), Frank Higginbottom (USA), Haldun Iplikcioglu (Turkey), Alessandro Januario (Brazil), Simon Jensen (Denmark), Hideaki Katsuyama

(Japan), Christian Krenkel (Austria), Richard Leesungbok (South Korea), Will Martin (USA), Lisa Heitz-Mayfield (Australia), Dean Morton (USA), Helena Rebelo (Portugal), Paul Rousseau (France), Bruno Schmid (Switzerland), Hendrik Terheyden (Germany), Adrian Watkinson (UK), and Daniel Wismeijer (Netherlands).

The 2009 version of the SAC classification scheme has received widespread acceptance in the dental profession and in the realm of dental education (Mattheos et al, 2014), where it has formed the basis of implant dentistry teaching in many predoctoral and postgraduate dental programs.

From its initial release in 2009, clinical techniques, materials, and technology have continued to evolve and, in early 2017, the ITI recognized that there was a need to review the SAC classification to ensure that it was still consistent with contemporary implant practice. A review group met in Zurich in October 2018, and again in Berlin in April 2019, to develop an updated SAC classification scheme. The primary aim of this review was to develop an updated SAC Assessment Tool, as this had been found to be clinicians' favored way of determining the classification of their patients' treatment needs. The publication of this book satisfies the secondary goal of the review: to document the rationale for this SAC Assessment Tool and the evolution of the SAC classification.

1.3 The Review Team

This text documents the proceedings of consensus meetings held by the ITI in 2018 and 2019. The following individuals contributed to the findings of this conference and the content of this publication (Figure 2):

Fig 2. Review team members.

Paolo Casentini	*Italy*	Dean Morton	*USA*
David Cochran	*USA*	Waldemar Polido	*USA*
Anthony Dawson	*Australia*	Lira Rahman	*Switzerland*
Luiz Gonzaga	*USA*	Mario Roccuzzo	*Italy*
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Ali Kökat	*Turkey*	Alejandro Treviño Santos	*Mexico*
William Martin	*USA*	Daniel Wismeijer	*Netherlands*

1.4 Potential Roles for the SAC Classification

On its surface, the SAC classification provides an assessment of the potential difficulty and risk of an implant-related treatment for a given clinical situation and serves as a guide for clinicians in both patient selection and treatment planning. In addition, it can also fulfill several additional roles.

Primarily, the classification scheme is aimed at providing clinicians with an objective and evidence-based framework against which they can assess clinical cases regarding the complexity of the planned treatment. This can then be used to assist them in deciding if they possess the necessary skills and knowledge to complete the treatment themselves, or whether referral to a more experienced clinician is indicated. With this capacity, they can build their experience in implant dentistry incrementally and minimize potential risk to their patients. Recently, the current SAC Assessment Tool validity was tested in regard to the agreement level between users, confirming its role as a clinical decision-making tool, as well as a valuable tool for the education of less experienced clinicians (Correia et al, 2020).

The SAC classification can also act as a checklist for more experienced clinicians to help them ensure that all relevant risks have been considered in the patient assessment and treatment planning phases of care.

Communication is a vital part of any step of patient management. In this regard, the SAC classification can aid in communication between clinicians as well as between them and their patients. The classification facilitates communication between colleagues by providing a known framework to exchange information: a shorthand that all involved clinicians are familiar with. When dealing with patients, clinicians can use the SAC classification of their situation to illustrate to patients the complexity and risks associated with their care. As such, it becomes an important tool not only in treatment planning but in the informed consent process as well.

Finally, the SAC classification can aid educators in developing training programs that gradually introduce increasingly more complex cases to their students, allowing an incremental development of knowledge and skill.

1.5 Using this Book

This book is intended to support your use of the SAC Assessment Tool that can be found at www.iti.org. Many sections of this publication are also supported by additional online information from the ITI Academy, the ITI's e-learning platform, including learning modules and assessments, congress lectures, clinical cases, and Consensus Conference papers.

To view this additional material in full and for free, you need to be an ITI Member and logged in at www.iti.org.

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The SAC Assessment Tool distills the content of this book in an easy-to-use process that takes you through each step necessary to identify the degree of complexity and potential risk involved in individual clinical cases. To start your assessment, scan the QR code to the left or click on the link.

CHAPTER 2:

The Rationale Behind the Updated SAC Classification

A. DAWSON, C. STILWELL

Please refer to chapter 1, section 1.5 for information on the prerequisites for accessing the additional online information from the ITI Academy via the QR-codes and links provided in this chapter.

Please note that to view this additional material in full and for free, you need to be an ITI Member and logged in at www.iti.org.

2.1 Definitions

Case type: A class of implant-supported prostheses that share similar defining characteristics. For example, implant-supported crowns for single-tooth replacements, or short-span implant-supported fixed dental prostheses replacing three or four teeth and supported by two implants.

Process: The implant dentistry "process" is defined as the full range of issues pertaining to assessment, planning, management of treatment, and subsequent maintenance of the implant and prosthetic reconstruction; it does not merely refer to the clinical treatment procedures that are involved.

Normative classification: In this context, "normative" relates to the classification that conforms to the norm, or standard, for a given clinical situation in implant dentistry. The normative classification relates to the most likely classification of a case type. The final classification of a specific case may differ from the normative classification for the case type as a result of individual risk factors.

Timing of implant placement and loading: Loading and placement protocols have been investigated by the ITI at its last four Consensus Conferences. Hämmerle and coworkers (Hämmerle et al, 2004) defined the timing of implant placement relative to the event of tooth removal in a site, relating this to healing events rather than a specific time frame. This classification is detailed in Table 1.

Table 1 Implant placement protocols (Hämmerle et al, 2004).

Classification	Definition
Type 1	Implant placement immediately following tooth extraction and as part of the same surgical procedure
Type 2	Complete soft tissue coverage of the socket (typically 4 to 8 weeks)
Type 3	Substantial clinical and/or radiographic bone fill of the socket (typically 12 to 16 weeks)
Type 4	Healed site (typically more than 16 weeks)

Review article from the 3rd ITI Consensus Conference on the Placement of Implants in Extraction Sockets by Hämmerle and coworkers (2004).

Implant loading protocols were also the subject of consensus conference reviews. At the Fourth ITI Consensus Conference, Weber and coworkers (Weber et al, 2009) defined the timing of implant loading relative to its placement. These descriptions are summarized in Table 2.

Table 2 Implant loading protocols (Weber et al, 2009).

Classification	Definition
Conventional loading	Greater than 2 months subsequent to implant placement
Early loading	Between 1 week and 2 months subsequent to implant placement
Immediate loading	Earlier than 1 week subsequent to implant placement

Review article from the 4th ITI Consensus Conference on Loading Protocols by Weber and coworkers (2009).

Most recently, the relationships between the timing of implant placement (relative to the time that the tooth in the placement site was extracted) and the timing of loading of the implant with a provisional or definitive prosthesis in partially dentate patients were addressed by Gallucci et al (Gallucci et al, 2018). The outcomes of this review, correlating the evidence for the various combinations of placement and loading protocol, are summarized in Table 3. Protocols that had multiple high-quality studies were deemed scientifically and clinically validated (SCV) and could be seen as suitable for routine use by appropriately trained and experienced clinicians. Clinically documented (CD) approaches had less support in the published literature but did possess reasonable long-term clinical documentation to allow their use in specific situations. Finally, clinically insufficiently documented (CID) protocols lacked sufficient scientific evidence and clinical documentation to be recommended for use. This review built on previous consensus meetings where definitions of the placement and loading protocols were developed.

Table 3 Summary of placement and loading protocols (Gallucci et al, 2018).

	Loading protocol		
	Immediate restoration/loading (Type A)	Early loading (Type B)	Conventional loading (Type C)
Implant placement protocol			
Immediate placement (Type 1)	Type 1A CD	Type 1B CD	Type 1C SCV
Early placement (Type 2–3)	Type 2–3A CID	Type 2–3B CID	Type 2–3C SCV
Late placement (Type 4)	Type 4A CD	Type 4B SCV	Type 4C SCV

Review article from the 6th ITI Consensus Conference on Implant Placement and Loading Protocols in Partially Edentulous Patients by Gallucci and coworkers (2018).

Risk factors: This term refers to any preexisting condition, treatment option, or material choice that may have an adverse effect on the outcome of treatment. These factors have the potential to influence the final SAC classification of a clinical situation.

2.2 Assumptions

This classification assumes that appropriate training, preparation, and care are devoted to the planning and implementation of treatment plans. No classification can adequately address cases or outcomes that deviate significantly from the norm. In addition, it is assumed that clinicians will be practicing within the bounds of their clinical competence and abilities. Thus, within each classification, the following general and specific assumptions are implied:

- Treatment will be provided in an appropriately equipped dental office with an appropriate aseptic technique.
- Adequate clinical and laboratory support is available.
- Patients' medical conditions are appropriately addressed.
- The surgical procedures are planned and provided following recognized protocols.
- The prosthesis is designed, manufactured, and managed correctly.

ITI Learning Module Surgical Setup for Office-Based Implant Surgery by Waldemar Daudt Polido.

2.3 Is the Clinician a Risk Factor?

With the increasing popularity of dental implant treatments with both patients and dental practitioners, the risks associated with the clinician are often overlooked. Derks and coworkers (Derks et al, 2016) described a situation where implant complications from peri-implantitis were significantly correlated with the level of experience of the dentist who was completing the restorative part of the treatment. In this study of real-world treatments, general dentists were 4.3 times more likely to be associated with a peri-implantitis problem than were restorative specialists. While this result may relate to confounding biases in the data set used in this study, which could not be controlled due to the nature of the data, it is still a somewhat disconcerting statistic.

It is also a concern in connection with the incidence of complaints and medicolegal claims relating to implant treatments that are increasing in many jurisdictions. In some regions, professional indemnity insurers are charging additional premiums for particular groups of practitioners who are participating in implant dentistry. These insurance companies do so on the basis of their own actuarial research, which indicates additional risk associated with these treatments in the hands of specific cohorts of practitioners.

2.3.1 Factors impacting the clinician as a risk factor

2.3.1.1 EXPERIENCE

It is a widely held truism in the surgical disciplines in medicine that a surgeon needs to complete between 50 and 100 procedures to be considered competent. The real evidence for this is somewhat less clear. Jerjes and Hopper (2018) described a number of investigations into the relationship between experience and postoperative outcomes in both

medical and dental surgical disciplines. Their review found no consistent relationship between these factors. However, it did find evidence that there was often a threshold level of experience below which surgeons could be expected to have greater incidence of problems, indicating that there was a "learning curve" related to most surgical procedures. This threshold value varied between disciplines and studies.

In a systematic review of the relationship between surgeon experience and implant failure rates, Sendyk and others (Sendyk et al, 2017) noted that this relationship did not correlate with the surgeon's specialty but was significantly related to the number of implants that the surgeon had placed. In an earlier study, Lambert and coworkers (Lambert et al, 1997) found similar outcomes, noting that implant failure rates were two times higher for inexperienced surgeons (ie, who had placed less than 50 implants) compared to those of surgeons who had placed 50 or more implants. They also noted that the first nine implants placed by a surgeon under training where at the greatest risk of failure. These findings could be reasonably accepted as showing a relationship between experience and outcomes in implant treatments.

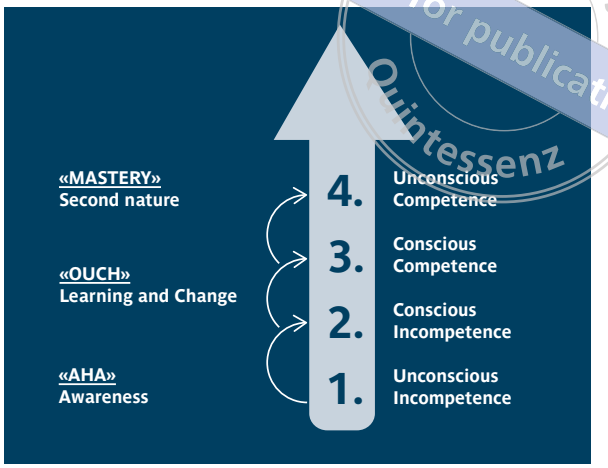


Fig 1. The Conscious Competence Learning Model.

2.3.1.2 TRAINING

Training is another area of consideration. The Conscious Competence Learning Model (Curtiss & Warren, 1973) is an accepted description of how people learn new skills. In this model (Figure 1), four stages of learning are described:

1. **Unconsciously incompetent:** Here the person knows little about what they are doing. They cannot comprehend the potential difficulties involved in a process, and they often feel that they are performing the task to a high standard. They do not know what they do not know, and this is a major impediment to learning.
2. **Consciously incompetent:** The learner comprehends that they fall short of ideal performance and understands their knowledge deficit. Making mistakes at this stage is often a key part of learning.
3. **Consciously competent:** The person at this level of learning can perform the task to an acceptable standard, but this requires concentration and attention to detail.
4. **Unconsciously competent:** The individual at this level has had so much practice that they can perform this task without conscious effort. These people can be good teachers in the technique but can also make the task appear "too easy" to casual observers.

Training in implant dentistry needs to address each of these learner levels. For the *unconsciously incompetent*, clinical training must address their knowledge deficit and stress best-practice approaches to treatment provision. Simulations of treatment provision, and mentoring by more experienced clinicians, can assist the *consciously incompetent* practitioner to pass through this level without endangering patients under their care. Mentoring will also benefit the *consciously competent* clinician by supporting their incremental development of skills. Finally, for the unconsciously competent clinician, training must support their focus on practicing in a reflective and consistent manner. The unconsciously competent clinician is at some risk of complacency and overconfidence and must make a conscious effort to remain focused on current best practices and the evolution of techniques in implant dentistry. They are also something of a risk to less knowledgeable and less skillful colleagues who might observe them providing patient care and conclude that these treatments are more straightforward than they really are.

2.3.1.3 SELF-ASSESSMENT OF ABILITY

Another way of considering this journey of skill development is the so-called "Dunning-Kruger Effect" (Kruger & Dunning, 1999). This describes a form of cognitive bias that leads to individuals overestimating their own ability because they lack sufficient knowledge and understanding of what they are doing to realistically measure their level of skill. It is only through painful discovery of the limitations of their ability that they can begin to learn. This correlates well with the unconsciously incompetent level described above. It is also a potentially dangerous issue with a novice clinician involved in providing a potentially complex treatment to a patient.

Congress lecture Surgical Treatment of Esthetic Disasters by Waldemar Daudt Polido.

2.3.1.4 SHARED LEARNING

Training in implant dentistry is provided at a number of levels. At its simplest, clinicians learn from each other as they progress along the learning curve. This is the process by which most of today's acknowledged "experts" learned these skills in the period during which implant treatments were evolving.

With implant dentistry now an established discipline, learning from shared experience is valuable for clinicians who have a sound understanding of implant treatments. Here, the consciously and unconsciously competent clinicians can benchmark their understanding against that of others.

However, this approach is unlikely to be effective if the individuals (eg, those in the unconsciously incompetent group) sharing their experiences do not fully understand the significance of what these experiences represent. This model is often popular today with younger practitioners who learn from colleagues via online forums, but this represents a real risk of being "the blind leading the blind."

2.3.1.5 SHORT TRAINING COURSES

Similar observations might be made about the short, company-led programs. Often the aim of this training is to make practitioners aware of the processes needed to handle that company's componentry, and thus these programs often focus on the "how" rather than the "why" or "why not." Also, due to the brevity of these courses, the biologic and biomechanical principles involved in implant treatments must be greatly abbreviated or are simply not covered at all. Unfortunately, this method can be fraught with danger to patients and cannot allow for a focus on best-practice protocols, as these concepts may be unknown to those learning.

2.3.1.6 STRUCTURED EDUCATION AND TRAINING

The most effective training comes from structured programs that provide a sound basis for patient selection and treatment. These courses address the basic sciences that underpin successful treatment, introduce protocols for patient assessment and selection and treatment planning, and then provide candidates with the opportunity to perform actual treatment and patient maintenance with assistance and guidance from more experienced mentors. Given the breadth of the topics to be covered, these programs must extend over longer periods compared with other approaches. Thus, these programs can be expensive in terms of time and money and difficult to fit in alongside daily practice, leading to under-utilization of this type of education and training.

Intuitively, one might expect that better-quality training would result in fewer complications or failure. While this is generally accepted in health care, little evidence is available to support these conclusions. Certainly, patients and regulators see this connection as true, and this forms that basic assumption that underpins mandated continuing professional development requirements.

2.3.2 Reducing clinician-related risk

2.3.2.1 RECOGNIZING "HUMAN FACTOR" RISKS

What have been described as "human factors" are becoming recognized as sources of error in health care provision. Much of the research in this area comes from the commercial aviation industry, but these findings are beginning to permeate into health care safety considerations.

A second edition of Renouard and Rangert's book about risk factors was published in 2008 (Renouard & Rangert, 2008) and brought the topic of experience and human factors to the discussion.

In a recent review of these factors and their influence in dental implantology, Renouard and coworkers (Renouard et al, 2017) described five hazardous attitudes or behaviors that are potentially detrimental to safe practice. Originally identified in aviation, these types are:

1. **Impulsiveness:** The urge to get things done quickly, without necessarily considering potential dangers.
2. **Anti-authority:** The attitude held by some practitioners that rules, regulations, and protocols are for others, and do not pertain to them.
3. **Invulnerability:** Practitioners who believe that adverse outcomes only happen to others, and not to them.
4. **Macho:** The belief that a practitioner must be constantly demonstrating their superiority over others. While this is mostly a male trait, it can affect women as well.
5. **Resignation:** The belief that no matter what a practitioner does, it will not have any effect on the outcome.

2.3.2.2 STRESS AS A RISK FACTOR

Renouard and coworkers also discuss stress as a potential problem. While the stress response is adaptive (ie, it is protective against external threats), it can have negative effects in a health care setting where the stress is mostly self-induced. Stress factors such as time pressures, staff problems, and interpersonal frictions between the dentist and the patient can all have a negative effect on performance. Stress tends to reduce the practitioner's ability to rationally think through a problem and rather promotes the use of automatic responses, which may be incorrect or unhelpful. These factors are well studied in the medical literature as well, as it relates to many daily issues, like less sleep, financial problems, and health or family issues (West et al, 2006).

2.3.2.3 MITIGATING THE HUMAN FACTOR ISSUES

To counter these "human factor" issues, Renouard recommends using techniques that have been developed for the airline industry to address safety problems: so-called "crew resource management." The concept of the "sterile cockpit" where all extraneous activity is banned during high-risk periods, such as take-off and landing, can be transferred to the

dental implantology setting for use during critical periods of treatment provision. Strict division of responsibilities between team members also reduces stress and "information overload." Additionally, checklists can be very useful in concentrating attention on critical steps, especially in highly procedural tasks such as those seen in medicine and dentistry. This approach has also been promoted by other authors (Gawande, 2009; Pinsky et al, 2010). Here the SAC classification can be used as a checklist to ensure that all factors relevant to the patient's presentation are assessed and incorporated into treatment plans.

2.3.2.4 CLINICIAN RISK FACTOR IN RELATION TO OTHER SOURCES OF RISKS

The clinician is central to most decisions and their practical application in implant treatment. Risks in implant dentistry can be attributed to four main sources: the patient, the treatment approach, the biomaterials, and the clinician. This relationship between the clinician, the materials, and the patient factors was first described by Chen and Schärer in 1993 (Chen & Schärer, 1993). Further, Buser and Chen (Buser & Chen, 2008), published on a model that also illustrates the potential interactions between these factors, as shown in Figure 2.

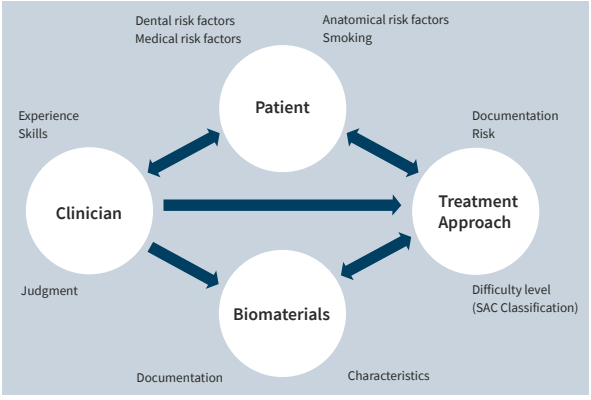


Fig 2. Potential sources of risk (Source: ITI Treatment Guide Vol. 3 "Implant Placement in Post-Extraction Sites")

In this model, the clinician has a potentially disproportionate influence: they select the patient, the treatment approach, and the biomaterials, and they subsequently carry out the treatment on the patient. Thus, a flaw or shortcoming in their knowledge or skills will put their patient at greater risk of adverse outcomes. Therefore, in answer to the question posed earlier, we must conclude that the clinician has the potential to be a significant risk factor.

Can the SAC classification assist in reducing risk? By focusing the attention of the clinician on potential risk factors, it should ensure that the clinician-related risk is mitigated. However, the review group did not believe that the clinician could be considered as a factor in determining the SAC classification for a case, as they were not confident that all clinicians could accurately self-assess their ability. Nonetheless, discussions such as this may assist individuals in progressing along their own learning journey and improve their ability to control this potential risk.

2.4 Classification Rationale

In the 2009 version of the SAC classification (Dawson & Chen, 2009) the main determinants of the classification were:

- The esthetic risk
- The complexity of the process
- The risks of complications

These factors were considered for each of the treatments considered in this publication, and a normative SAC classification was derived for each of these case types. Further modifiers were considered that might increase or decrease the level of complexity or risk, but these did not change the normative classification for the case type.

In this update, the normative classifications have been reviewed, but they have not altered greatly. These are still based on the factors above, with an increased emphasis on the SAC classification as a risk management instrument.

The updated SAC Assessment Tool now allows users to derive a SAC classification for their specific case based on the pattern of risk factors that they report. Risks are considered in four broad areas:

- **General risks:** These are the issues normally identified during anamnesis and the initial clinical assessment and are mostly patient related.
- **Esthetic risk:** Esthetic issues are often the patient's only way of measuring the treatment outcome. This is more than a consideration of "is the treatment site visible during function and/or smiling, and are the peri-implant mucosal tissues visible?" but also includes other factors described by Martin and coworkers (Martin et al, 2017) in their discussion of the esthetic risk assessment for single-tooth implant prostheses. Esthetic risk assessment for more extensive tooth replacement situations have also been considered.
- **Edentulous esthetic risk:** When patients undergo complete loss of teeth, several unique clinical factors specific to this patient subset can have a significant influence on esthetic outcomes. The edentulous esthetic risk assessment will highlight these factors as they influence particular case types.
- **Surgical risk:** Factors influencing the complexity and risk of the surgical phase of treatment.
- **Prosthetic risks:** Factors relating the implant-supported prosthesis; for example, the clinical processes involved, the mode of manufacture, the materials used, and the design employed.

Each of these areas will be considered in more detail later in this book.

CHAPTER 3:

Risks in Implant Dentistry

A. DAWSON, W. MARTIN, W. D. POLIDO

Please refer to chapter 1, section 1.5 for information on the prerequisites for accessing the additional online information from the ITI Academy via the QR codes and links provided in this chapter.

Please note that to view this additional material in full and for free, you need to be an ITI Member and logged in at www.iti.org.

3.1 Principles of Risk Management

All interventions in health care carry some risk of failure, complications, or other suboptimal outcomes. Implant treatments are no different.

The risk management cycle is a term used to define a process aimed at limiting the incidence of adverse outcomes, and their impact.

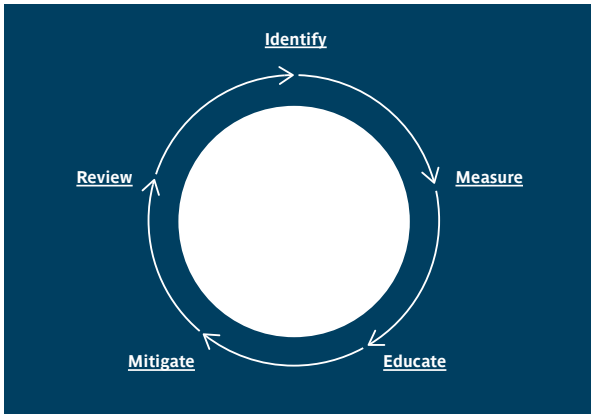


Fig 1. The risk management cycle.

In general, this cycle aims to:

- **Identify** potential problems
- **Measure** the incidence of these adverse outcomes and the impact that they have
- **Educate** users about these potential problems
- Develop strategies to **mitigate** the incidence or effect of these problems
- **Review** the effectiveness of these mitigation strategies

As indicated in Figure 1, this is a continuous process where outcomes are monitored, and refinements are made to mitigation strategies to incrementally improve process outcomes.

In implant dentistry, the users refer to patients and clinicians. However, the process remains the same. Although it is not usually referenced in such terms, effective practice in most areas of health care, including implant dentistry, follow the basic principles of risk management. A common dental practice example of this might be the management of dental caries. Here, our modern preventive approach to caries management centers on identifying risk factors (eg, patient behavior/diet, salivary function, oral microflora, plaque retentive restorations, etc) and measuring their impact. We then can focus on reducing risk by attempting to mitigate these risks through patient education and risk-reduction focused treatments. We then continue to monitor our patient's progress and the success of our interventions.

The importance or severity of a risk can be considered in terms of the likelihood of that risk being realized and the impact or significance associated with the outcome that follows. These situations are often tabulated in a risk matrix, an example of which can be seen in Table 1.

While we often concentrate our efforts on mitigating the risks of high-impact outcomes, like implant failure, it must also be noted that less dire outcomes that are more common, such as peri-implant disease, may be more important.

Table 1 An example of a risk matrix.

LIKELIHOOD \ IMPACT	Negligible	Minor	Moderate	Significant	Severe
Verly Likely	Low Med	Medium	Med Hi	High	High
Likely	Low	Low Med	Medium	Med Hi	High
Possible	Low	Low Med	Medium	Med Hi	Med Hi
Unlikely	Low	Low Med	Low Med	Medium	Med Hi
Very Unlikely	Low	Low	Low Med	Medium	Medium

3.2 The SAC Classification as a Risk Management Tool

The SAC classification is essentially a tool that assists practitioners to identify risks so that they can educate their patients about these potential problems as part of the informed consent process. Clinicians then use their understanding of these risks to plan treatments that minimize risk. Patients are then monitored after the completion of treatment to identify problems that might arise as early as possible, thus allowing intervention to minimize the impact of the problem on the ongoing quality of treatment outcomes.

This review of the SAC classification system incorporated this risk-management focus on risk identification, the likelihood of this problem arising, and the potential impacts of these risks on treatment outcome. Three subgroups in the review team each looked at one major area of risk factors. A "Systems" group reviewed general patient-related risk factors and worked to develop concepts in the SAC Assessment Tool workflow and algorithm. The "Surgical" and "Prosthetic" groups looked at surgical and restorative risk factors respectively, concentrating on risks associated with the treatment approach and technologies. The results from the deliberations of these groups represent a consensus opinion of the risk factors most likely to influence dental implant treatments.

3.3 General Risks

A. DAWSON, J. KLEINHEINZ, A. MURAT KÖKAT, D. WISMEIJER

A structured approach to patient assessment and treatment planning aims to identify all factors that have the potential to have some impact or influence on our treatment. Such a structured approach has been promoted by the ITI in its Academy Learning Module "Structured Assessment and Treatment Planning" (Weber, 2015), and the sequence and steps in this process are illustrated in Figure 2.

ITI Learning Module Structured Assessment and Treatment Planning by Hans-Peter Weber.

Identification of potential risk factors occurs relatively early in this process—during the information-gathering phase that incorporates anamnesis, clinical examination, imaging, and other investigations.

Identification of general risk factors is almost always done in the anamnesis and clinical examination. These factors relate to potential problems arising out of the patient's medical and dental history and their presenting condition. These general factors fall into three main clusters:

- Patient medical factors
- Patient-related attitudinal/behavioral factors
- Site-related factors

3.3.1 Patient medical factors

Most implant patients present with a range of historical and ongoing medical issues that may have an impact on implant treatment. The following were considered the most significant.

3.3.1.1 MEDICAL FITNESS

A patient's current health status has the potential to influence their fitness to undergo treatment, and also how well they will heal after implant surgery.

The American Society of Anesthesiologists (ASA) has developed a physical status classification and risk management tool that is widely used to assess patients' fitness for surgical interventions. The ASA Physical Status classification system (Doyle et al, 2019) is detailed in Table 2.

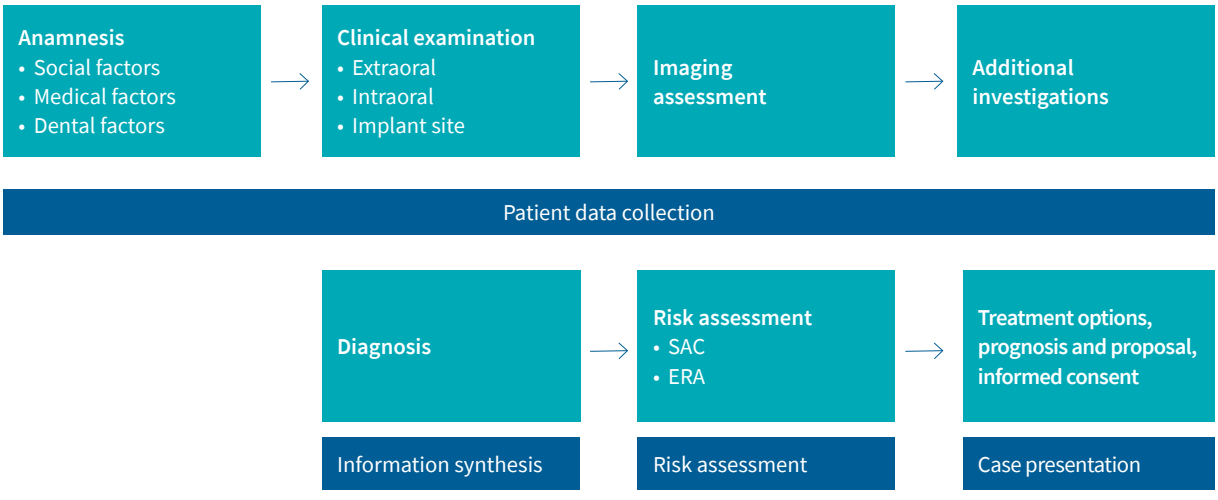


Fig 2. A structured approach to patient assessment and treatment planning.

Table 2 The ASA Physical Status Classification.

ASA PS Classiciation	Definition
ASA I	A normal healthy patient
ASA II	A patient with mild systemic disease
ASA III	A patient with severe systemic disease
ASA IV	A patient with severe systemic disease that is a constant threat to life
ASA V	A moribund patient who is not expected to survive without the operation
ASA VI	A declared brain-dead patient whose organs are being removed for donor purposes

Healthy patients (ASA I) and those with mild, well-controlled systemic disease (ASA II) are generally good candidates for implant surgery. Some patients identified as ASA III (severe systemic disease that may or may not be well controlled) can be treated with care but have higher risk and might best be managed by highly trained and experienced clinicians. While there may be some occasional indications for implant treatment in ASA IV cases, these treatments are high risk and should be restricted to specialist facilities where emergency medical care is readily available, and by highly experienced surgical teams.

ITI Learning Module Patient Medical Factors by Simon Storgård Jensen.

Medical status may also impact the speed of implant healing (usually a slowdown) and the esthetic outcome of treatments. For example, conditions associated with abnormal scarring after surgery, such as the development of keloid scars, may impact esthetic outcomes.

3.3.1.2 MEDICATIONS

Pharmaceutically active substances include prescription medications, over-the-counter medicines, herbal remedies, dietary supplements, and recreational substances. All of these may have an influence on implant treatment either directly through their influence on implant healing and/or peri-implant tissue health, or indirectly through their effects on the patient's behavior.

Review article from the 6th ITI Consensus Conference on Medication-Related Dental Implant Failure by Vivianne Chappuis and coworkers (2017).

ITI Learning Module Pharmacology with Relevance to Dental Implant Therapy by Stephen Barter.

Possibly of most importance relating to implant surgery are the antiresorptive drugs used to manage osteoporosis. These medications have been linked to a condition known as medication-related osteonecrosis of the jaws (MRONJ) that can also arise following surgical interventions involving the facial skeleton (Figure 3). The risk of MRONJ arising is related to the type of medication (usually biphosphonates), the dosage used and the duration of therapy (as some types of antiresorptives accumulate in facial bones). Antiresorptives with higher potency are usually administered via intravenous route, and hence they are associated with greater risk. This condition can be very difficult to treat and is usually associated with significant discomfort and disfigurement. In cases where there is a history of intravenous treatment, such as in patients with metastatic bone disease or Paget's Disease, the risks are such that implant treatment would normally be contraindicated.

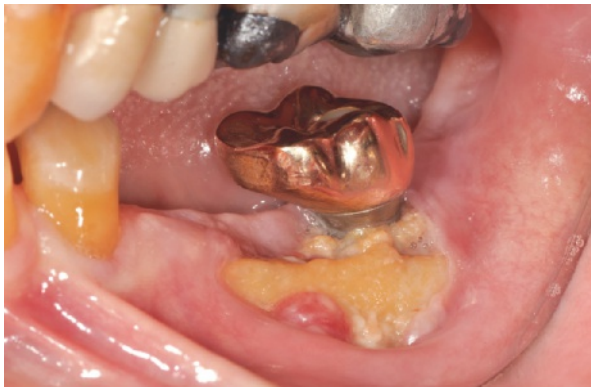


Fig 3. MRONJ associated with an implant in the mandibular left molar region.

3.3.1.3 RADIATION

Radiotherapy can have a dramatically adverse effect on bone healing. Osteoradionecrosis can arise following surgery in irradiated bone due to the reduction in blood supply to affected bone. This effect is dose related. The dosage to the area where implant placement is planned is the significant consideration, rather than the dosage used to treat the cancer. Doses of less than 50 Gray may allow implant placement with care. Doses of greater than 50 Gray to the area of interest would likely contraindicate implant placement. Time after radiation therapy, and presence of other coadjutant factors, such as smoking and oral hygiene can also impact the rate of occurrence of osteoradionecrosis of the jaws (Aarup-Kristensen et al, 2019).

3.3.1.4 GROWTH STATUS

Implants act in a similar way to ankylosed teeth to retard the development of surrounding bone. As such, placement of implants in growing individuals is normally contraindicated. These implant-supported prostheses can become unesthetic and/or nonfunctional due to apparent infraocclusion as a

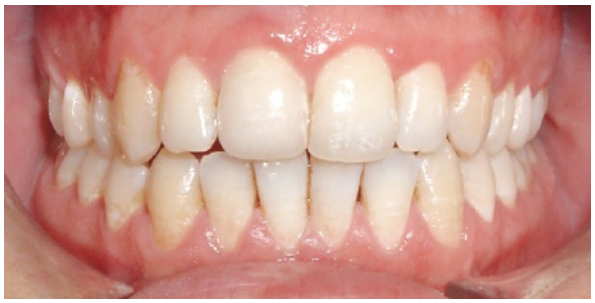


Fig 4. Five-year follow-up of an implant-supported crown replacing the maxillary right central incisor.

Fig 5. 15-year follow-up. Note the difference in incisal edge between implant-supported crown and adjacent natural teeth, due to continuous growth and extrusion of natural teeth.

result of the continued growth of the alveolar bone supporting adjacent teeth. This issue can also arise in older patients, as facial growth can continue—albeit at a very slow rate—well into maturity. The following case demonstrates the esthetic issues that can arise. An implant-supported crown replacing the maxillary right central incisor 5 years after placement in a 24-year-old male patient is seen in Figure 4. Ten years later, there is a significant difference in incisal edge position between the implant-supported crown and the adjacent natural teeth, due to continuous growth and extrusion of natural teeth. The implant crown remained stable (Figure 5).

3.3.2 Patient attitudes/behaviors

3.3.2.1 SMOKING HABIT

Tobacco smoking is related to increased risks of implant failure and peri-implant disease (Heitz-Mayfield & Huynh-Ba, 2009). There is some evidence of a dose-related effect, and that this is mediated by nicotine and other tobacco-derived chemicals that compromise wound healing, the immune response, and increase the risk of scarring. Ideally, patients should cease smoking prior to implant placement, as there is evidence that reducing their smoking habit acts to reduce risk. There is a paucity of evidence relating cannabis use or vaping (electronic cigarettes) to implant failure, but caution is advised when treating patients practicing these habits.

Review article from the 4th ITI Consensus Conference on History of Treated Periodontitis and Smoking as Risks for Implant Therapy by Lisa J. A. Heitz-Mayfield and Guy Huynh-Ba (2009).

3.3.2.2 COMPLIANCE

A patient's willingness and/or ability to comply with instructions is an important factor in any complex treatment where maintenance is vital to long-term success, and where following instructions is essential for optimal treatment outcomes in the short term. Noncompliant patients are more likely to experience problems with treatment and are less likely to follow the necessary steps to overcome these issues. Poor compliance might best be considered relative contraindication for implant therapy until the patient can become motivated to support their treatment.

3.3.2.3 ORAL HYGIENE

Bacterial biofilm accumulation has been associated with the development of peri-implant mucositis and peri-implantitis (Salvi & Zitzmann, 2014), and measures to regularly remove these deposits are the prime strategy for preventing the development of these biologic complications. If patients are unwilling or unable to perform these oral hygiene procedures, implant therapy should be delayed until they can do so. Alternatively, other forms of prosthetic reconstruction might best be considered.

Review article from the 5th ITI Consensus Conference on the Effects of Anti-infective Preventive Measures on the Occurrence of Biologic Implant Complications and Implant Loss by Giovanni E. Salvi and Nicola U. Zitzmann (2014).

3.3.2.4 PATIENT EXPECTATIONS

Unrealized expectations are often the trigger of patient complaints to statutory bodies, or to initiation of legal proceedings against treating practitioners. This risk is only amplified by the expense and invasiveness of implant treatment.

Communicating realistic expectations to patients, and managing their desired outcomes, is an important part of the ongoing consent process. A patient may have high and realistic expectations due to their social position or employment, and managing these situations can be challenging. Patients may also have unrealistic expectations, and managing these can often be virtually impossible. An extreme example of such a situation might involve a patient with body dysmorphic disorder. Unless these expectations can be managed, it is best not to proceed with implant rehabilitation.

3.3.3 Site-related factors

3.3.3.1 PERIODONTAL STATUS

A history of treated periodontal disease has been associated with an increased risk of biologic complications (Heitz-Mayfield & Huynh-Ba, 2009), as has the presence of active periodontal disease with periodontal pockets greater than 5 mm in depth. As an elective rehabilitative treatment, an implant-supported prostheses should not be considered until all active oral diseases are under control. Where implant treatment is planned, treatment to manage the periodontal disease prior to implant placement is mandatory.

Review article from the 4th ITI Consensus Conference on the History of Treated Periodontitis and Smoking as Risks for Implant Therapy by Lisa J. A. Heitz-Mayfield and Guy Huynh-Ba (2009).

3.3.3.2 ACCESS

Implant treatment involves the use of instruments that can occupy more physical space than conventional handpieces. During surgical procedures, the use of templates in conjunction with the surgical handpiece, twist drills, and drivers can consume more vertical space, requiring a large mouth opening by the patient. If there is insufficient space, treatment cannot proceed without changes to instrumentation. Limited (but adequate) space can make treatment more difficult, but insufficient space will need adjunctive treatment to make more space if implant placement and restoration is still desired. The use of a measuring device (such as the Straumann Diagnostic-T; Figure 6) during the consultation visit can assist in identifying situations where access will be difficult. This device identifies the amount of space needed to fit the head of the handpiece with the shortest Straumann kit twist drill (33 mm) at the site of planned implant placement.

3.3.3.3 PREVIOUS SURGERIES IN THE PLANNED IMPLANT SITE

Previous surgeries in the site of a planned implant can result in hard and soft tissue changes that may complicate implant placement and healing. Scarring from these surgeries (Figures 7 and 8) is also often associated with reduced vascularity that may have a negative influence on healing. While a single previous surgical treatment in a site may only have a small impact, multiple surgeries are likely to significantly increase the risk of problems.

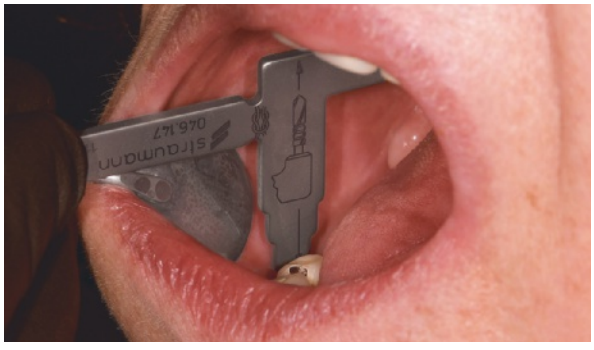


Fig 6. Clinical use of a Diagnostic-T (Straumann, Basel, Switzerland) to assess available space for surgical instrumentation.

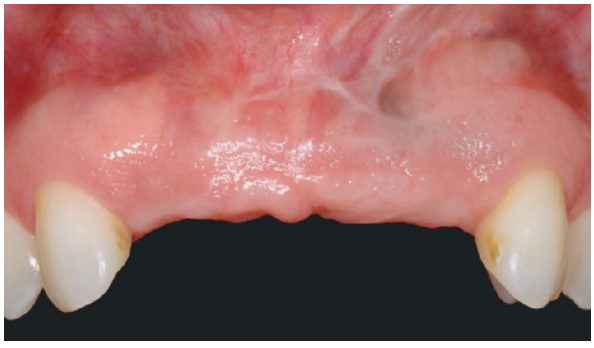


Fig 7. Clinical evaluation of patient missing maxillary central and lateral incisors with evidence of previous surgical procedures.

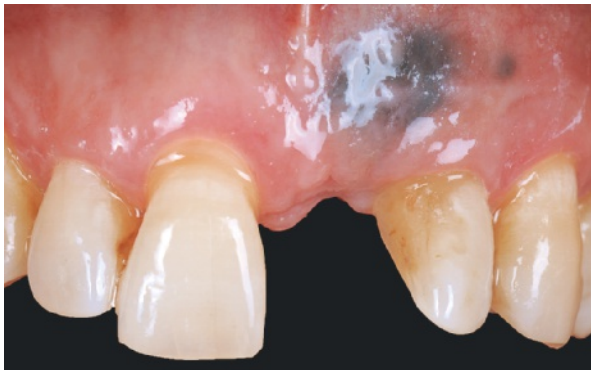


Fig 8. Clinical evaluation of patient missing tooth 21 with evidence of previous surgical procedures.

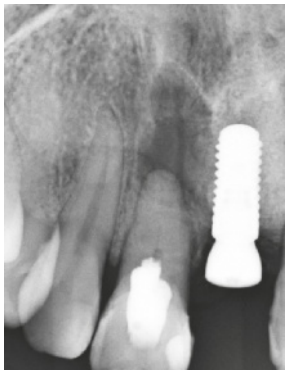


Fig 9. An apical infection adjacent to a recently placed implant can infect this site as well.

3.3.3.4 NEARBY PATHOLOGY

As a general rule, elective treatments such as implant therapy are only provided once all other pathologic conditions have been managed. However, there are situations where this may not be either possible or practical. Notwithstanding this, pathologies that may have an adverse effect on implant healing, or the risk of biologic complications, must be managed before implants are placed. For example, apical periodontitis affecting a tooth in another quadrant might be managed simultaneously with implant treatment. However, apical periodontitis related to a nonvital tooth adjacent to the planned implant site (Figure 9) must be managed prior to implant placement.

3.4 Esthetic Risk

W. MARTIN, V. CHAPPUIS, D. MORTON, D. BUSER

Esthetic issues apply where the implant restoration and the surrounding mucosal margin will be visible during normal functional activity or when the patient smiles. Smiles are as unique to individuals as the treatment necessary to maintain their natural appearance. Implant therapy in the esthetic zone can be a challenging process, as patient demands on esthetics coupled with preexisting deficiencies in the anatomy can present obstacles to obtain ideal results. Failure to achieve esthetic and functional results with dental implants could lead to disastrous situations that would require additional surgical and restorative procedures in an attempt to correct the compromise (Buser et al, 2004; Levine et al, 2014).

Consequently, not all implant treatments will have associated esthetic risk. It is therefore important for clinicians to understand their patient's desires and to perform a thorough initial clinical examination to highlight any potential obstacles that may present as a challenge in achieving an ideal esthetic outcome. Clinicians performing a rehabilitation must have a thorough understanding of tissue biology and the knowledge of all treatment modalities for a given clinical situation, as dental implants may not always be the primary choice. This series of modifiers has been discussed in detail in Chapter 3: "Preoperative Risk Assessment and Treatment Planning for Optimal Esthetic Outcomes" (W. Martin, V. Chappuis, D. Morton, D. Buser) found in "The ITI Treatment Guide, Volume 10: Implant Therapy in the Esthetic Zone: Current Treatment Modalities and Materials for Single-tooth Replacements" (Chappuis & Martin, 2017).

ITI Treatment Guide Vol. 10 Extended Edentulous Spaces in the Esthetic Zone: Current Treatment Modalities and Materials for Single-tooth Replacements by Vivianne Chappuis and Will Martin.

ITI Learning Module Esthetic Risk Assessment by William Christopher Martin.

Table 3 lists the factors that determine esthetic risk in the partially edentulous patient. The esthetic risk assessment (ERA) table was developed to assist clinicians in the diagnosis and planning of treatment in the esthetic zone and to identify clinical situations that could contribute to an esthetic compromise, thus assisting the clinician in determining the SAC classification of the case. It should be noted that, by definition, a case for which there is some esthetic risk (ie, the restoration margin is visible) would have a classification of at least *Advanced*.

Congress Lecture Pre-treatment Analytics to Maximize Longevity of Treatment Outcomes in the Esthetic Zone by William Christopher Martin.

3.4.1 Medical status and smoking habit

The impact of medical issues such as health status and smoking relate primarily to the predictability of the healing process. These issues have been discussed previously.

3.4.2 Gingival display at full smile

The level to which the planned implant restoration and its surrounding mucosal tissue is exposed during function and smiling is a major factor, defining whether the site is considered esthetic or nonesthetic. Special consideration should be given to the assessment of the position of the lip line and subsequent display of teeth, gingival tissues, and papillae and their potential impact on esthetic risk. Greater exposure of this area is associated with increasing esthetic risk. If soft and hard tissue defects exist that cannot be addressed surgically, prosthetic planning for gingival tissue replacement should be initiated before placing the dental implant(s). Situations associated with soft and hard tissue defects show the highest degree of complexity and thus the highest risk of esthetic failure.

Table 3 Esthetic Risk Assessment (ERA; taken from: "ITI Treatment Guide, Volume 10: Implant Therapy in the Esthetic Zone: Current Treatment Modalities and Materials for Single-tooth Replacements" [Chappuis & Martin, 2017])

Esthetic risk factors	Level of risk		
	Low	Medium	High
Medical status	Healthy, uneventful healing		Compromised healing
Smoking habit	Nonsmoker	Light smoker (≤ 10 cigs/day)	Heavy smoker (> 10 cigs/day)
Gingival display at full smile	Low	Medium	High
Width of edentulous span	1 tooth (≥ 7 mm)[1] 1 tooth (≥ 6 mm)[2]	1 tooth (< 7 mm)[1] 1 tooth (< 6 mm)[2]	2 teeth or more
Shape of tooth crowns	Rectangular		Triangular
Restorative status of neighboring teeth	Virgin		Restored
Gingival phenotype	Low-scalloped, thick	Medium-scalloped, medium-thick	High-scalloped, thin
Infection at implant site	None	Chronic	Acute
Soft tissue anatomy	Soft tissue intact		Soft tissue defects
Bone level at adjacent teeth	≤ 5 mm to contact point	5.5 to 6.5 mm to contact point	≥ 7 mm to contact point
Facial bone wall phenotype*	Thick-wall phenotype, ≥ 1 mm thickness		Thin-wall phenotype, < 1 mm thickness
Bone anatomy at alveolar crest	No bone deficiency	Horizontal bone deficiency	Vertical bone deficiency
Patient's esthetic expectations	Realistic expectations		Unrealistic expectations

[1] Standard-diameter implant, regular connection
[2] Narrow-diameter implant, narrow connection
*If 3D imaging is available with the tooth in place

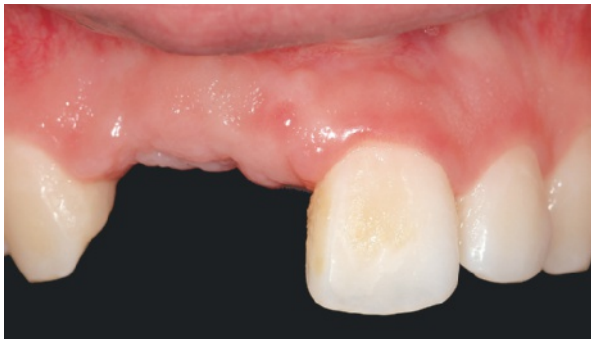


Fig 10. An extended edentulous situation highlighting a deficiency in soft and hard tissue support for implant restorations.

3.4.3 Width of the edentulous space

See also 3.7.1.1. Prosthetic volume.

When evaluating edentulous spaces for restoration, careful attention should be given to the materials planned to replace the missing tooth structure and their space requirements for long-term durability. As the interdental and interroot space decreases, the implant and restorative component options become limited, and the prosthetic volume for ideal restoration emergence and contours suffer, increasing the esthetic risk. When the edentulous space increases to include multiple missing teeth, the esthetic risk also increases due to the unpredictable nature of the interimplant soft and hard tissue support and the increased difficulty to maintain symmetric mucosal contours (Mirtrani et al, 2005; Mankoo, 2008). Esthetic risk can also be influenced by the location of the adjacent missing teeth, as extended spaces lateral to the midline increase the difficulty of maintaining harmonious tissue contours and restoration symmetry. Patients with adjacent missing teeth, including a lateral incisor, present a maximum esthetic risk when adjacent implants are planned (Figure 10).

ITI Learning Module Esthetic Planning for Implant-supported Fixed Dental Prostheses by Daniel S. Thoma.

Congress Lecture How to be Successful in Replacing Multiple Missing Adjacent Teeth in the Esthetic Zone by Hans-Peter Weber.

ITI Treatment Guide Vol. 6 Extended Edentulous Spaces in the Esthetic Zone by Julia-Gabriela Wittneben Matter and Hans-Peter Weber.

When combined with additional risk factors such as high lip line or a thin gingival phenotype, the placement of adjacent implants in extended edentulous areas in the anterior maxilla often represents a maximum esthetic risk. Site development for patients in this category is often mandatory before or during implant placement. The results of such procedures vary, with horizontal augmentation gains often superior to gains achieved in the vertical dimension.

3.4.4 Shapes of tooth crowns

One key to clinical outcomes in esthetic dentistry is the symmetry of the restorations and their shape, contours, and textures (Gallucci et al, 2007). If an implant restoration is mismatched with the adjacent tooth, this will greatly influence the appearance and final esthetic outcome (Figure 11). With the esthetic outcome strongly influenced by the symmetry of the final mucosal contours, the risk can often be reduced by the presence of square teeth (and, often, a thick gingival phenotype) (Stellini et al, 2013).

There is little question that square-triangular and triangular tooth shapes pose a greater risk, and that risk is most likely associated with the emergence anatomy and tissue support (Takei, 1980; Gobbato et al, 2013) (Figure 12). A high esthetic risk is evident when a triangular tooth shape is associated with localized periodontal defects and the loss of interproximal papillae. These patients will often require a dental implant restoration that is square shaped with broad contact areas, potentially compromising the final appearance. When confronted with this situation, modifying the contours of the adjacent tooth to match those of the implant restoration might be an option to maintain symmetry and avoid black triangles.

3.4.5 Restorative status of adjacent teeth

The restorative status of teeth surrounding the edentulous space and planned surgical area can have an influence on esthetic outcomes and should be addressed in the treatment plan. If the teeth are virgin (nonrestored), the esthetic risk can vary greatly, as their characteristics (thickness, translucency, optical properties) will play a role in the ability of the laboratory technician to create a restoration that accurately mimics the surrounding teeth. If the adjacent teeth have restorations (crowns or veneers) that extend into the gingival sulcus and surgery is planned in the area, an elevated esthetic risk exists (Richter & Ueno, 1973; Lindhe et al, 1987; Felton et al, 1991; Sanavi et al, 1998). Subgingival margins on adjacent teeth are often associated with recession subsequent to the placement of an implant, and esthetic complications can be associated with exposed restorative margins or an altered gingival architecture (Figure 13).

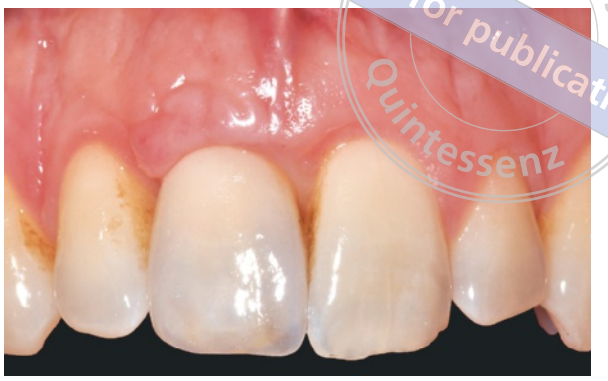


Fig 11. An implant restoration 11 with contours mismatched to those of the adjacent tooth.

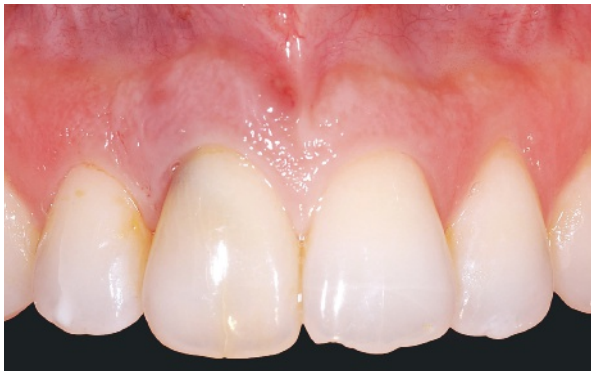


Fig 12. Triangular tooth shape associated with high-scalloped tissue architecture.

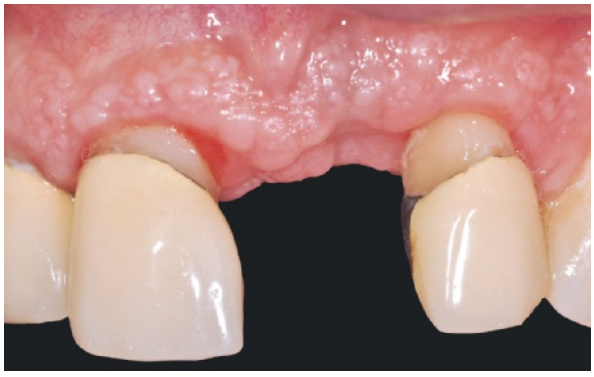


Fig 13. Exposure of crown margins of teeth 11 and 22 subsequent to extraction of tooth 21.

3.4.6 Gingival phenotype

Phenotypes are the description of physical characteristics of an individual and are considered an expression of their genotype. The characteristics of the gingival phenotype (thick or thin) at an implant site can influence the treatment approach (surgical and restorative) as well as the ability to achieve an acceptable esthetic outcome.

Thick gingival phenotype. A thick gingival phenotype presents a low esthetic risk when replacing single missing teeth in the anterior area. The gingival tissue in these patients is often characterized by a predominance of thick, broad-banded keratinized tissue that is typically resistant to recession after surgical procedures (Chen & Buser, 2014; Chen et al, 2009; Kan et al, 2003; Kois, 2001).

Thin gingival phenotype. A thin gingival phenotype is characterized by a high-scalloped gingival architecture that is often associated with attractive single-tooth implant outcomes. The successful maintenance of the soft tissue architecture depends on the support of facial bone and the periodontal support from the adjacent teeth (Cardaropoli et al, 2004; Kan et al, 2003; Kois, 2001; Weisgold, 1977). The health and proximity of adjacent structures as they traverse the connective tissues and epithelium is important to establishing and maintaining papillae. The thin and friable nature of the soft tissues is conducive to the formation and maintenance of natural and predictable interproximal papillae, but an increased esthetic risk is associated with the possibility of mucosal recession in situations where immediate implants are used (Chen & Buser, 2014; Chen et al, 2009).

3.4.7 Volume of surrounding tissues

Many of the factors in the ERA relate to the volume of the mucosal tissues and supporting bone in the implant site. Their influence on implant placement and restoration in a manner that will allow the development of esthetic symmetry and harmony with surrounding teeth and soft tissues is of critical concern. Issues that might compromise this tissue volume, such as crestal bone resorption and mucosal recession, will increase the esthetic risk and the level of treatment difficulty.

Bony support for peri-implant soft tissues is critical when esthetic risk is present (Belser et al, 1998; Buser & von Arx, 2000). One area where this issue has a great impact is in the support for papillae between teeth and implants (Choquet et al, 2001), or between implants (Tarnow et al, 2000; Tarnow et al, 2003). In a single-tooth case with intact papillae supported by the proximal bone crests on adjacent teeth, it is likely that the papillae can be maintained through proper implant selection and good surgical technique, thus leading to low esthetic risk. However, where bony support for the papilla is reduced by periodontal disease, deep subgingival restoration margins, or active infection, the risk of suboptimal outcomes is much higher. This issue can also arise when the mesiodistal space for implant placement is reduced, allowing crestal remodeling to compromise this supporting bone. Longer spans, involving the replacement of multiple missing teeth, can be very difficult in terms of developing the "natural" appearance of papillae between the prosthetic teeth (Buser et al, 2004), and the use of prosthetic soft tissue replacements may be necessary.

Congress Lecture Hard and Soft Tissue Management in the Esthetic Zone – Part I by Luca Cordaro.

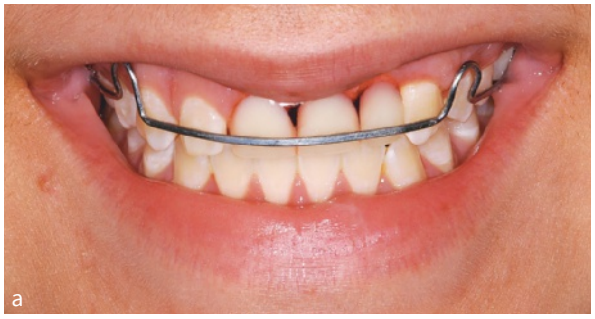
Congress Lecture Hard and Soft Tissue Management in the Esthetic Zone – Part II by Luca Cordaro.

3.4.8 Patient's esthetic expectations

Upon completion of the ERA table, the visual impact of low, medium, and high esthetic risk will educate the clinician and patient on the overall treatment risk for achieving an ideal implant-supported restoration. The esthetic risk factor that can determine whether the treatment should proceed is the patient's expectations. With patients who have high or unrealistic expectations combined with a high esthetic risk, treatment should be avoided, or the patient should be advised of the potential shortcomings in treatment with an attempt to change their expectations to be more realistic. It is not uncommon to have patients presenting a high esthetic risk that understand the limitations to treatment and are willing to accept a compromised esthetic outcome (eg, longer contacts, closed embrasures, pink ceramics) (Figure 14).

When advising patients with high esthetic expectations, informing them of limitations in outcomes before the treatment is considered a risk in itself. However, failure to inform patients of treatment limitations before treatment can lead to compromised esthetic outcomes being interpreted by the patient as a complication and in many situations unacceptable.

ITI Learning Module Principles of Evaluating Esthetic Outcomes by Charlotte Stilwell.



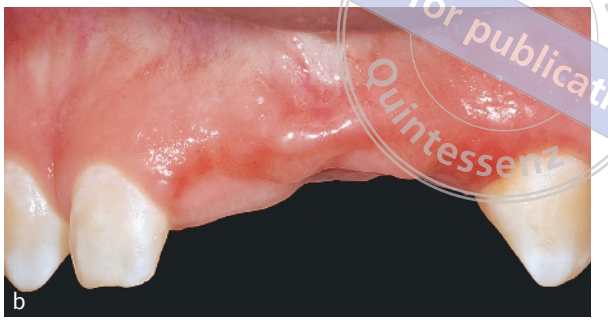


Fig 14 a–b. (a) A patient with missing maxillary anterior teeth and associated high esthetic risk. (b) View of the edentulous area.

3.5 Edentulous Esthetic Risk Assessment (EERA)

L. GONZAGA, W. MARTIN, D. MORTON

In fully edentulous scenarios, esthetic issues occur when implant-supported prostheses inadequately support or blend with the facial structures, teeth, smile line, and residual alveolar ridge. The EERA is a component of the SAC classification. It functions as an independent tool capable of identifying key risk factors that influence esthetic outcomes. These factors are relevant when managing patients with a terminal dentition or when fully edentulous. The systematic use of the EERA checklist during the diagnosis and planning phase can decrease the risk of esthetic as well as technical and biologic complications.

Publications focusing on management of the fully edentulous mandible with prostheses supported by dental implants report high survival and success rates, and low rates of esthetic complications (Polido et al, 2018; Malo et al, 2011). These findings are likely due to the anatomy of the lower two-thirds of the lower one-third of the face, including the lip and its surrounding muscles and the influence of the prosthesis on facial support, the smile line, and phonetics (minimal disruption of speech seal) (Figure 15).

Alternatively, the management of the fully edentulous maxilla is more challenging and requires meticulous planning (Desjardins, 1992). The challenges associated with management of the maxilla are well-recognized and can be associated with specific anatomical characteristics, bone resorption patterns, quality of bone, need for prosthetic volume, importance of emergence profile, oral hygiene limitations, influence of the teeth and hard tissue during speech, and the importance of the prosthesis for facial and dental esthetics (Schnitman, 1999; Zitzmann & Marinello, 2000; Taylor, 1991). In 2017, Pollini and coworkers emphasized the

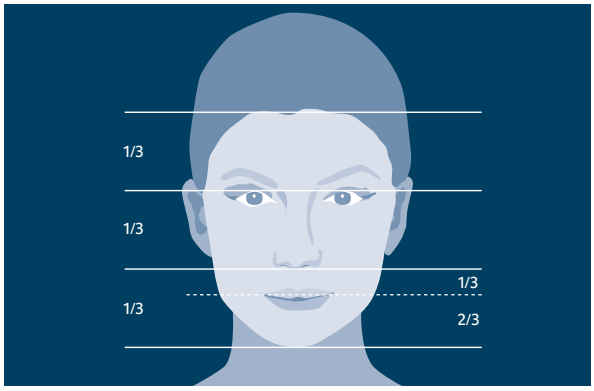


Fig 15. Facial proportions.

challenges associated with management of the edentulous maxilla and developed the lip-tooth-ridge (LTR) classification. The LTR classification offers a guide for treatment planning the edentulous maxilla for fixed or removable prostheses (Figure 16). Utilization of the LTR classification assists clinicians in identifying esthetic risk based on a combination of lip dynamics as well as structural risk based upon prosthetic space availability.

It should be recognized that treatment of the edentulous maxilla will increase esthetic risk due to the need for optimal facial and lip support, the relationship between the ideal tooth position, the lip, and the alveolar ridge, as well as the need for specific prosthesis design to minimize phonetics complications or speech issues.

Congress Lecture The Edentulous Maxilla – Fixed vs. Removable for Esthetic Outcomes by Nicola Ursula Zitzmann.

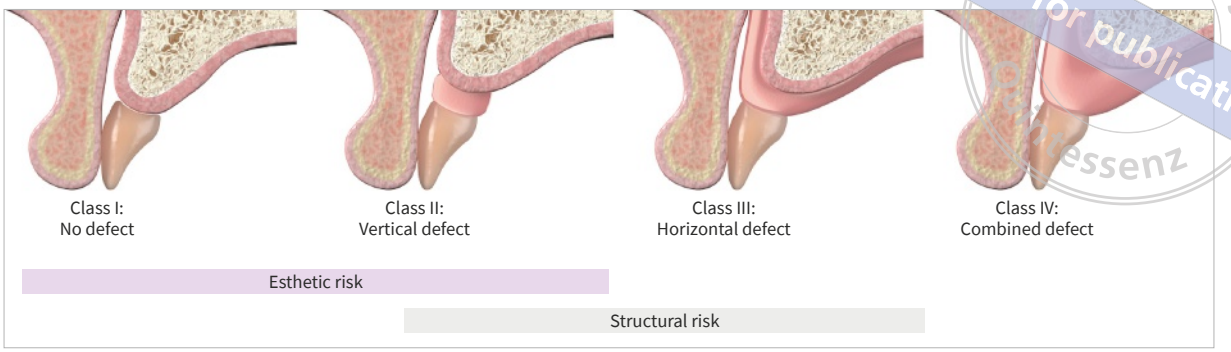


Fig 16. The LTR classification. Visual representation of the four major indications related to the maxillary complete edentulous situation. Note that the classification is based on the defect present between the ridge and the lip horizontally and the prosthetic tooth and ridge vertically. The bone availability for implant placement does not influence the type of indication. (From Pollini et al, 2017, with permission).

The EERA consists of seven clinical risk factors that influence esthetic outcomes when managing fully edentulous arches with implant-assisted prostheses. Table 4 highlights these risk factors. Several factors have been addressed in publications by Zitzmann and Marinello in 1999 and as mentioned previously Pollini and coworkers in 2017. An important key factor when utilizing the EERA is to consider all treatment approaches and options (ie, fixed vs. removable and variations). Doing so will ensure that the clinical and diagnostic findings assist in the identification of information-driven treatment choices. This approach often identifies the need for either an analog (wax try-in) and digital tooth arrangement to determine and review potential treatment outcomes and to effectively utilize the EERA (Figure 17).

Table 4 Edentulous esthetic risk assessment (EERA).

Esthetic risk factors - Edentulous	Level of risk		
	Low	Medium	High
Arch	Mandible		Maxilla
Facial support (fixed)	Alveolar process provides adequate facial support	Minimal changes tolerated by the patient	Flange required for adequate facial support
Facial support (removable)	Flange provides adequate facial support	Minimal changes tolerated by the patient	Insufficient space for a flange
Labial support	Designed tooth position provides satisfactory labial support	Minimal changes tolerated by the patient	Designed tooth position causes unsatisfactory labial support
Upper lip length	Long upper lip (> 20 mm)		Short upper lip (< 20 mm)
Buccal corridor* (atrophic ridge)	Removable prosthesis		Fixed prosthesis
Smile line	No display of the ridge(s) at full smile (maxilla or mandible)		Display of the ridge(s) at full smile (maxilla or mandible)
Maxillomandibular relationship	Class I	Class II	Class III

*Desired narrow corridor in definitive prosthesis.

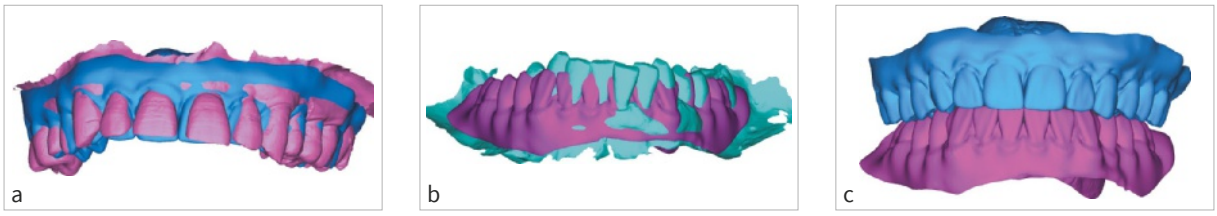


Fig 17 a–c. Example of a digital tooth arrangement for a full-mouth rehabilitation.

3.5.1 Facial support

The determination of optimal or required facial support is a critical factor during the planning process. This is primarily because the facial tissues are supported either by the patient's existing bone and teeth or, in an edentulous scenario, the buccal and labial denture base extensions and the position of the denture teeth. Anatomical factors that influence facial support are residual alveolar ridge, tooth position, and subnasal structures (lip length and thickness, philtrum, nasolabial crease). Facial support is critical because it plays an important role in patients' perception of esthetics and can be specifically associated with both a retrognathic appearance of the maxilla or for compensation of prognathism (Zitzmann & Marinello, 1999). In fully edentulous scenarios, any need for extraoral facial tissue support should be evaluated with and without the existing prosthesis in place from frontal and lateral views (Figure 18).

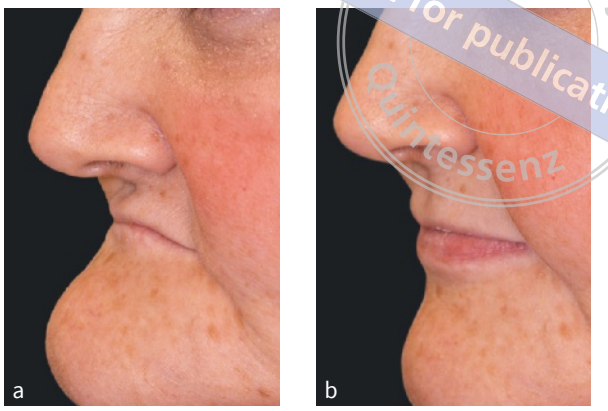


Fig 18 a–b. Pre- and post-placement of maxillary and mandibular overdentures demonstrating improvement in facial support.

3.5.2 Labial support

When evaluating dentate patients, the alveolar ridge shape and cervical crown contour of the central incisors have the greatest influence in labial support (Zitzmann & Marinello, 1999). This influence is altered for the edentulous maxilla due to the absence of tooth support and the resorptive bone pattern after extraction. These factors result in the need for the prosthesis to provide lost support. Other factors that influence buccal and labial tissue support include the musculature (body) of the upper lip, the dry vermilion/vermilion border and tooth length/position. Patients with a thin upper lip should also be considered high esthetic risk as any deficiencies in ridge form, implant position, or type and design of the definitive prosthesis will be magnified and hard to overcome.

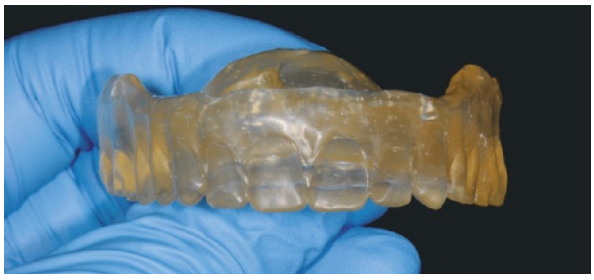


Fig 19. Duplicated denture with labial flange removed.

For edentulous patients planned for implant-supported treatment in the maxilla, the need for prosthesis-provided facial and labial tissue support is a critical component that will assist in the choice of fixed or removable prosthetic solutions. This evaluation should first be performed without the denture in place at full smile. If the residual alveolar ridge is displayed during smiling, the use of a labial flange may be advisable to prevent esthetic problems (Taylor, 1991). In these situations, if a fixed solution is desired, surgical intervention will be necessary, not only to overcome potential esthetic issues, but to create space for the prosthesis and implant components (aka prosthetic volume). The second evaluation would be to determine if the patient can tolerate a "flangeless solution." This can be tested by duplicating the denture, removing the flange, and evaluating labial support (Figures 19 to 21).

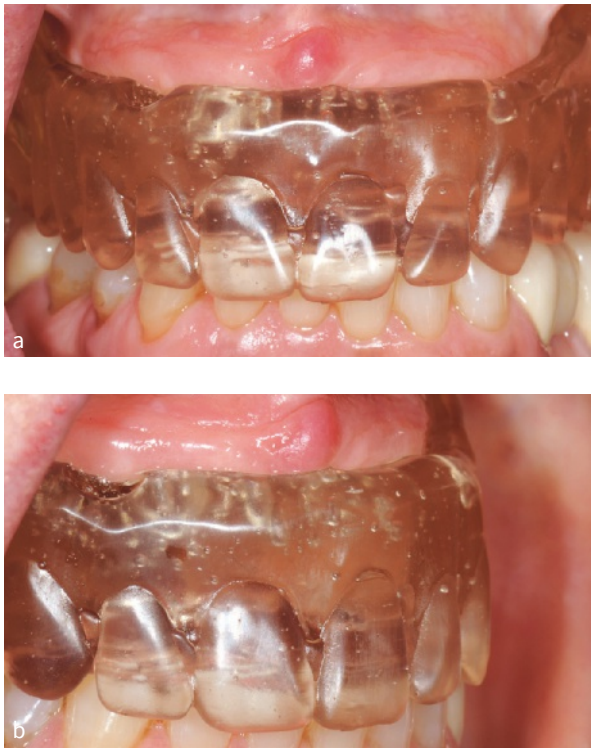


Fig 20 a–b. Try-in of "flangeless" duplicated denture.

Fully edentulous patients that presented with a thin/short lip that are restored with a flangeless prosthetic solution can sometimes demonstrate a transverse upper labial crease during smiling, which can be seen as an esthetic compromise (Figure 22). This transverse labial crease can be influ-

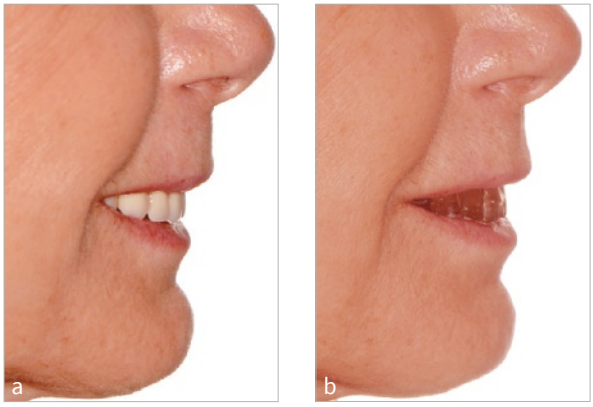


Fig 21 a–b. Labial support evaluation with and without labial flange on prosthesis.

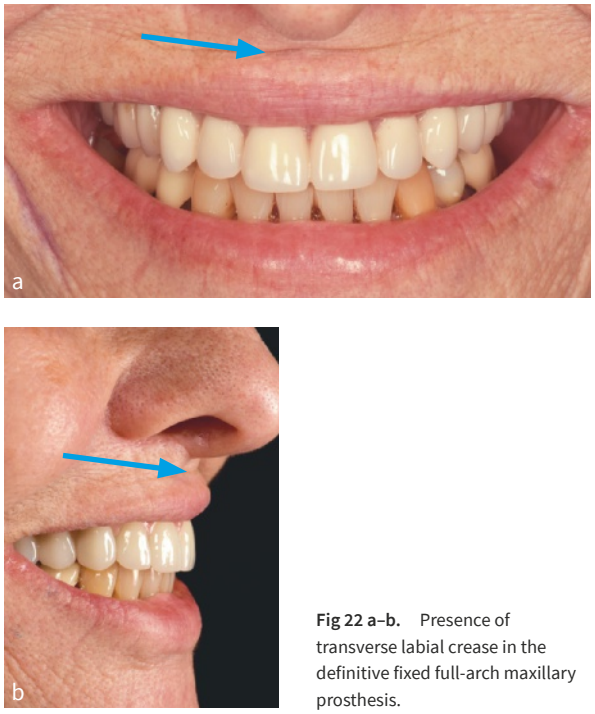


Fig 22 a–b. Presence of transverse labial crease in the definitive fixed full-arch maxillary prosthesis.

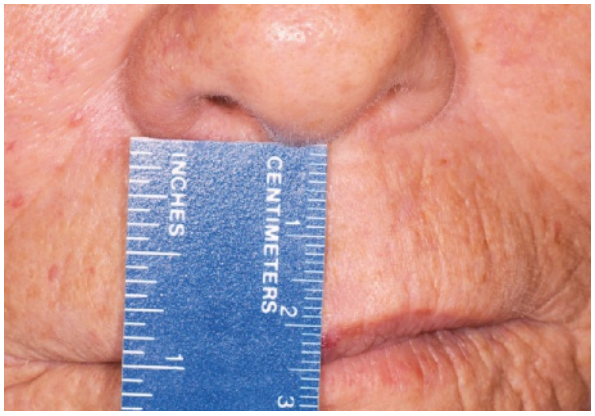


Fig 23. Measurement for upper lip length.

enced by extraoral clinical factors as well. In 2017, Beer and Manestar linked this crease to the presence or hyperactivity of the depressor septi nasi muscle. In their study, they examined 100 consecutive female volunteers, finding that 38% of women older than 40 years presented with an upper labial crease at rest, and 70% presented with a crease during smiling. With this, during the diagnostic phase, the treatment team should evaluate for the presence of a transverse upper labial crease prior to the initiation of care and discuss with the patient possible compromise or need for future cosmetic treatment with botulinum toxin.

3.5.3 Upper lip length

The upper lip position and length is one of the most important elements in anterior esthetics; its static and dynamic assessment will play a crucial role in deciding the type of prosthetic design for the patient (Pollini et al, 2017). For patients with an edentulous maxilla, the position of the lip line at dynamic smile is directly influenced by the length of the upper lip. The length of the upper lip is measured from the base of the column (subnasal) to the philtrum location (Figure 23). The upper lip length will change over the individual's life and continues to strongly influence the display of maxillary teeth. Average lip lengths of 21 to 25 mm were related to 2.2 mm tooth display in the maxilla and 1 mm tooth display in the mandible (Vig & Brundo, 1978). A short upper lip (less than 20 mm measured at rest) represents a higher risk to display the connection or association between the prosthesis and the patient's residual ridge. In patients with a short upper lip, the incisal edges and facial surfaces of the maxillary anterior teeth will be visible in repose, whereas in patients with a long upper lip, the incisal edges and facial surfaces will be covered (Zitzmann & Marinello, 1999).

3.5.4 Buccal corridor

Smile attractiveness is influenced by many additional factors, including the dental midline, smile line and incisal plane convexity, tooth exposure, occlusal plane convexity and cant, buccal corridor, proportion, and symmetry. One of the more controversial aspects of smile attractiveness pertains to buccal corridor size, defined as the negative space between the buccal surfaces of the maxillary teeth and the corners of the mouth during a smile (Martin et al, 2007). In their study, Martin and coworkers reported that laypeople rated smiles with small buccal corridors as significantly ($P < .05$) more attractive than those with large buccal corridors (Figure 24). When evaluating the dentate patient for a tooth/implant combination rehabilitation, the buccal corridor should be evaluated and addressed during the diagnostic phase to determine if orthodontic intervention is necessary or desirable.

In the completely edentulous patient, the pretreatment evaluation of the buccal corridor will play a larger role, as es-

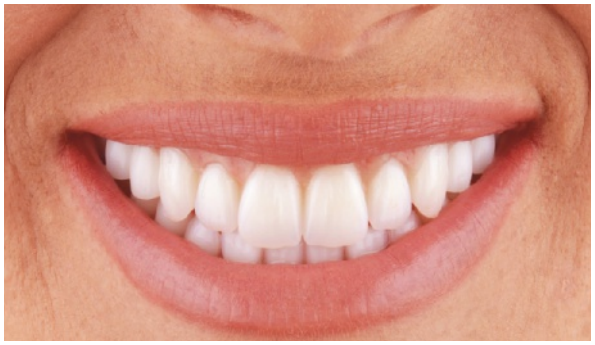


Fig 24. Evaluation of narrow buccal corridor in a maxillary and mandibular hybrid patient.

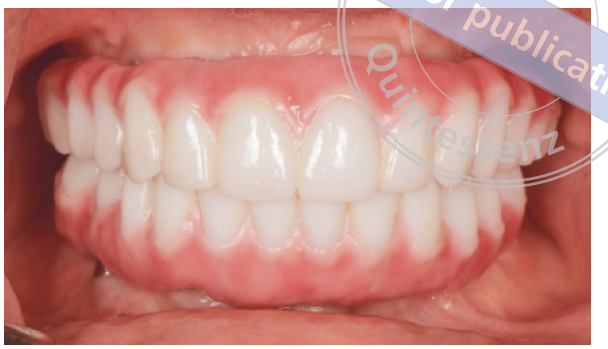


Fig 25. Evaluation of excessive horizontal positioning of teeth in the implant-supported prosthesis to minimize the buccal corridor.

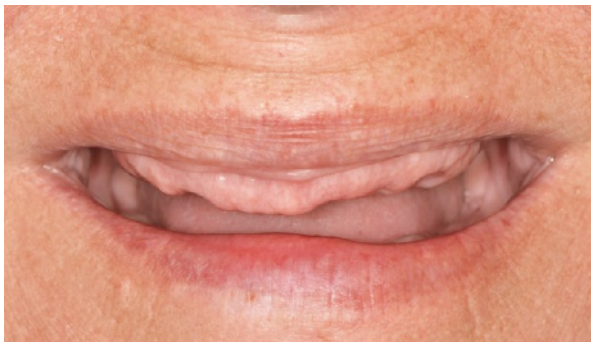


Fig 26. Clinical example of visualization of the residual alveolar ridge at full smile.

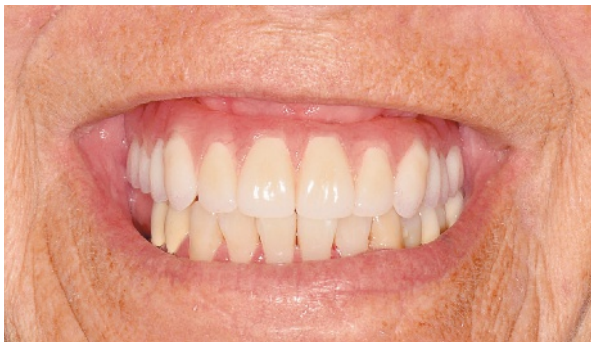


Fig 27. An example of a high smile line and short lip length exposing the transition line, resulting in esthetic compromise.

thetic limitations will be influenced by the position and size of the residual alveolar ridge and its relation to the corners of the mouth at full smile. When the maxillary arch is narrow and the patient desires a fixed solution, the prosthesis will extend horizontally off the ridge, creating the possibility for food entrapment and greater difficulty with maintenance (Figure 25). Depending on the amount of bone resorption and the desired prosthetic design, the residual ridge geometry may need to be surgically modified to ensure a convex emergence profile that will prevent food entrapment and promote appropriate oral hygiene procedures compatible with sustainable oral health (Stein, 1966). In clinical scenarios involving narrow arches, either surgical modification of the ridge prior to implant placement or a removable prosthesis (overdenture) should be considered as an alternative.

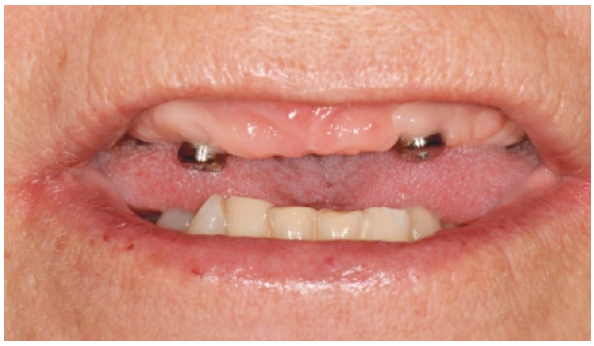


Fig 28. Clinical example of visualization of the residual alveolar ridge with dental implants at full smile in a patient planned for a fixed solution.

3.5.5 Smile line

Based on the upper lip position, Tjan and coworkers (1984) classified the smile for dentate patients as high, medium, or low, with medium and high corresponding to 80% of the population. The smile line is evaluated during a forced smile with and without the prosthesis in place. In edentulous maxillary scenarios, patients that display the residual maxillary ridge when smiling will carry a higher risk of esthetic complications, as the type of prosthesis planned and preimplant surgical intervention will play a significant role in outcomes (Figure 26). In patients with a high smile line and advanced alveolar ridge resorption, implant-supported overdentures are often preferred due to the added support the labial flange can provide. Extreme esthetic risk is found in patients with a combination of a high smile line and short lip length. Such situations increase the potential for display of the transition line, leading to esthetic compromise (Figure 27). In situations with improper diagnosis and treatment planning, complications can arise that result in unrestorable implants (Figure 28).

3.5.6 Maxillomandibular relationship

Vertical and horizontal bone resorption of the residual alveolar ridges has been described to occur after extraction of the teeth (Carlsson et al, 1967; Tallgren, 1966; Tallgren, 1967). Resorption has been described in complete denture patients after 5 to 25 years (Pollini et al, 2017). The residual ridges undergo a primary resorption that occurs mostly during the first 6 months after extraction, followed by a continuous, steady resorption over the years (Tan et al, 2012; Van der Weijden et al, 2009). Variations in resorption characteristics between the maxilla and the mandible result in altered maxillomandibular relationships. During the diagnostic and planning phase of treatment, the maxillomandibular relationship is evaluated in the clinical setting, often aided by a cephalometric study. Of particular importance during this evaluation is the identification of the proposed or planned tooth position and the relationships between tooth position and the residual ridges. This is mandatory to allow for the evaluation of the skeletal relationship at the correct vertical dimension of occlusion. An ideal setup will show the amount of intermaxillary space, the Angle classification, the need for a denture flange lip support, and the position of the anterior teeth related to potential implant positions.

Discrepancies in interarch relationships, such as crossbites, extreme Angle Class II or III jaw relationships, and an extremely reduced maxillomandibular space can lead to biomechanical risks in the prosthetic phase. It is therefore important to recognize these potential problems at an early stage (Wismeijer et al, 2010).

ITI Treatment Guide Vol. 4 Loading Protocols in Implant Dentistry – Edentulous Patients by Daniel Wismeijer, Paolo Casentini, German Gallucci and Matteo Chiapasco.

Solutions to these problems may include:

- Not placing implants
- Orthognathic surgery prior to implant placement
- Bone grafting procedures
- An alternative prosthetic treatment plan that avoids the anticipated complications (eg, using a removable solution rather than a fixed prosthesis)
- In situations with inadequate intermaxillary space, reduction of the ridge height to allow for greater prosthetic volume

Patients with advanced atrophy of the alveolar ridge will often present in a Class III relationship, which is often due to the alveolar bone remodeling pattern, similar to patients with improper fitting dentures with excessive tooth wear. In severe situations, if a Class I relationship is desired, a removable prosthesis may be necessary.

Congress Lecture Management of Edentulous Arches by Dean Morton.

3.6 Surgical Risks

W. D. POLIDO

Several factors can influence the surgical risk when placing an implant, and they should be identified and addressed as part of the treatment plan. In some instances, they can be individually considered, but in the majority of the clinical presentations, there is an interaction between the different surgical modifying factors, as well as with the general, restorative, and esthetic factors. They can be analyzed in no specific order, but we recommend that all are checked in detail.

An inherent component of any surgical technique is the risk of a complication occurring. The risk of complication is related to a number of factors, including the complexity of the procedure, proximity to anatomical structures, esthetic factors, and the skill and experience of the clinician undertaking the treatment. The risk of complications may range from low to high and must be assessed for each implant site and for the technique(s) selected.

A further consideration is the consequence of a complication. If a complication can be managed without any adverse effect on the implant or restoration, then the complication may be regarded as low risk. If the complication results in adverse bone and/or soft tissue outcomes, the risk of long-term consequences may be medium to high depending upon the nature of the complication.

ITI Learning Module Surgical Complications and Management by Simon Storgård Jensen.

With the purpose of facilitating the decision tree and the risk assessment, we divided the surgical risk factors into four groups, or clusters: *anatomy*, condition of *adjacent teeth*, need for and type of *extractions*, and *surgical complexity*. Each cluster contains different factors that play a role in modifying the risk of a given clinical situation, from a single-tooth replacement to a complete edentulous rehabilitation. Surgical risk factors are classified as either low, medium, or high.

3.6.1 Anatomy

A comprehensive knowledge of oral anatomy is mandatory for anyone practicing implant surgery. Several surgical fac-

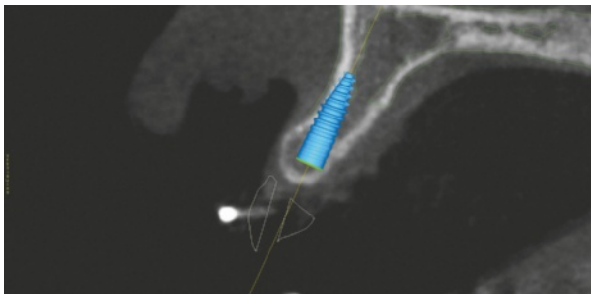


Fig 29. CBCT showing horizontal bone deficiency. Here a narrow ridge still allows placement of a reduced-diameter implant. Use of a regular-diameter implant may require additional grafting procedures.

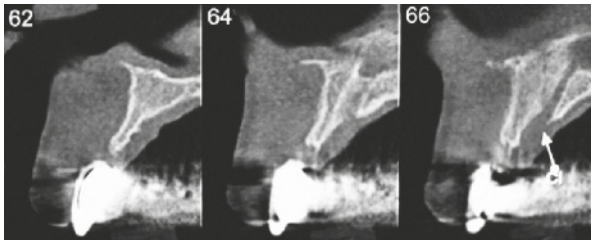


Fig 30. CBCT showing horizontal bone deficiency. A staged bone augmentation is indicated.

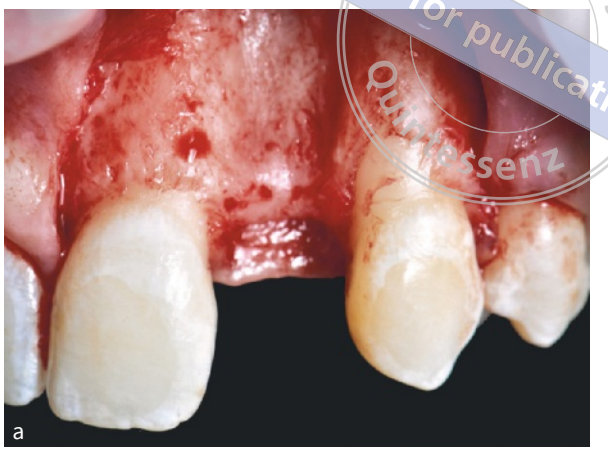
tors are directly related to the anatomy of a patient, and individual variations may be present.

A basic requirement for implant therapy is bone volume that is sufficient to support an implant of adequate length and width in its ideal restorative position (Buser & von Arx, 2000). Following tooth extraction, resorptive changes result in varying patterns and degrees of bone resorption, leading to reduced horizontal and vertical bone dimensions (Schropp et al, 2003). This in turn may lead to the need for bone augmentation procedures either prior to or at the time of implant placement (Chiapasco et al, 2009). The need for adjunctive bone augmentation procedures increases the difficulty of surgical treatment and requires a more in-depth knowledge of oral and maxillofacial anatomy.

3.6.1.1. BONE VOLUME – HORIZONTAL

When bone volume has adequate width for the planned implant, the risk is considered to be low, since no additional grafting procedures are necessary. Ideally, one should have a minimum of 2 mm of bone surrounding the implant, and a regular-diameter implant (3.5–4.5 mm) should be considered (Benic and Hämmerle, 2014).

With horizontal deficiencies, a simultaneous bone augmentation procedure may be carried out when the anticipated peri-implant defect presents with at least two bone walls (Chiapasco & Casentini, 2018). Small simultaneous horizontal augmentation procedures are regarded as moderately difficult to perform, requiring skill and experience in the use



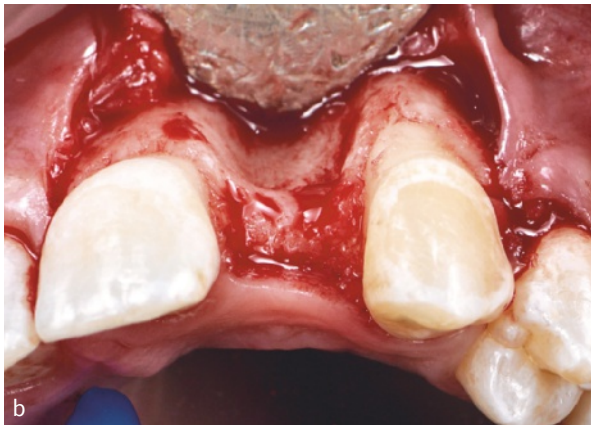


Fig 31 a–b. Clinical intraoperative view showing adequate vertical bone volume (a) and deficient horizontal volume (b) in a maxillary lateral incisor area. This is a high-risk situation requiring staged horizontal bone augmentation.

of barrier membranes and/or bone grafts and bone substitutes. In selected situations, the use of reduced-diameter implants (3.0–3.5 mm) can be considered, with simultaneous horizontal augmentation (Figure 29).

In esthetically sensitive sites, there may be a need for a simultaneous bone or soft tissue augmentation to optimize long-term esthetic outcomes (Benic & Hämmerle, 2014; Chiapasco & Casentini, 2018).

If bone is deficient in the horizontal dimension (Figure 30), and the selected implant cannot be placed in the ideal restorative-driven position, a staged grafting approach may be necessary, and the risk is considered to be high. Procedures associated with these types of defects, such as lateral bone augmentation with combinations of block and particulate grafts and/or space-maintaining GBR (guided bone regeneration) procedures (titanium-reinforced membranes, tenting procedures, titanium meshes) have a high degree of difficulty and require additional skill and experience. There is a commensurate increase in the risk of surgical and postoperative complications (Figure 31).

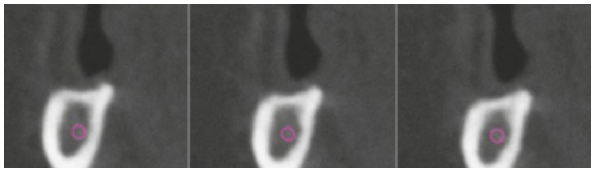


Fig 32. CBCT cross section of posterior mandible site. Note the extreme vertical ridge deficiency. A decision has to be made between short implants vs. staged vertical augmentation.

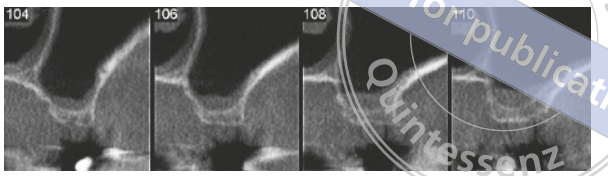
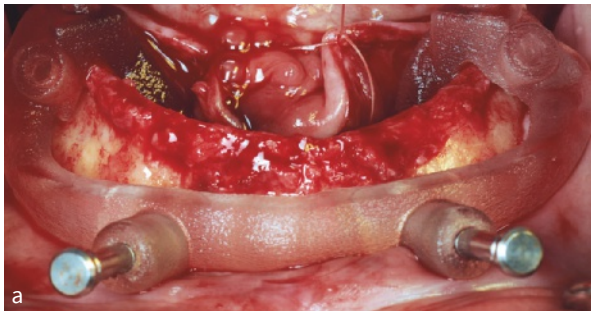


Fig 34. CBCT Illustrating vertical bone deficiency but good horizontal volume in the posterior maxilla. There is a need for a sinus floor augmentation procedure.



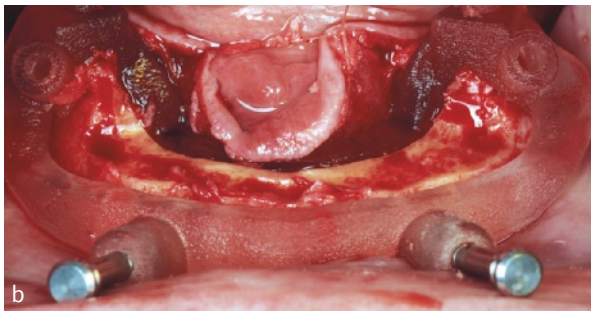


Fig 33 a–b. (a) Completely edentulous ridge, showing need for bone reduction (according to bone reduction guide). (b) Bone reduction performed according to the guide.

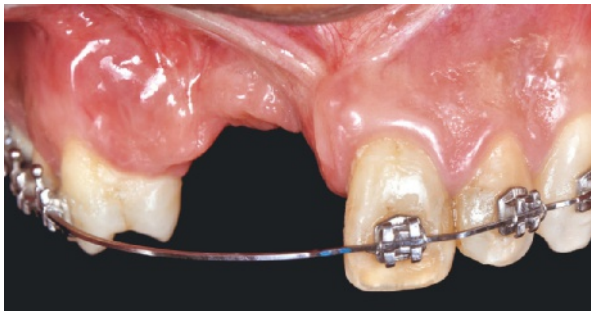


Fig 35. Clinical view of missing maxillary lateral and central incisors. Note large vertical deficiency, presence of soft tissue scars, and low frenulum insertion. Soft tissue management is as important as the management of the bone deficiency.

3.6.1.2 BONE VOLUME – VERTICAL

Adequate bone volume in the vertical dimension is directly related to the outcome of the implant and the restoration. Ideally, an implant with a minimum height of 8 mm should be considered.

Small crestal bone deficiencies may be managed without augmentation. However, the implant shoulder may be deeply positioned in relation to the mucosal margin. This may influence the subsequent restorative procedures and may complicate long-term maintenance of peri-implant tissue health.

If the presence of vital anatomical structures or advanced bone resorption reduces the height of bone in the vertical dimension, implants with shorter lengths may be considered. But the long-term survival of implants with less than 6 mm length is not well documented and may be reduced, although the complexity of placing shorter implants is smaller than staged vertical augmentation techniques (Papaspyridakos et al, 2018). When using short implants, a high crown-to-implant ratio may be expected, and splinting of the implants is recommended. Loading conditions have to be carefully controlled. At sites with reduced bone height, the proximity to vital anatomical structures can increase the risk of surgical complications. For these reasons, sites with small to moderate vertical bone deficiencies allowing placement of shorter implants or simultaneous smaller vertical augmentation should be regarded as having a moderate degree of difficulty (Figure 32).

In certain clinical situations, such as when treating a completely edentulous patient with a hybrid fixed solution, there may be a need for bone reduction in the vertical aspect to create space for the prosthesis. When vertical bone volume allows for implant placement but requires bone reduction, surgical requirements are more extensive, and the risk is considered to be medium (Figure 33).

At sites with significant vertical deficiencies (Figure 34), requiring a separate bone augmentation or a larger bone augmentation simultaneously with implant placement, risk is considered to be high. Techniques for vertical bone augmentation may include sinus and nasal floor grafts, vertical ridge augmentation using block grafts, barrier membranes and/or titanium meshes combined with autogenous bone grafts or bone substitutes, and distraction osteogenesis (Polido & Misch, 2021). These procedures have a high degree of difficulty and an increased risk of surgical complications (Chiapasco & Casentini, 2018). Clinicians are required to have a high level of clinical skill and experience to carry out these procedures successfully. They are particularly challenging and with increased risk in esthetic situations (Figure 35).

3.6.1.3 PRESENCE OF KERATINIZED TISSUE

Adequate volume and quality of gingival soft tissues is essential for the final and long-term stability of the treatment's results.

The presence of an adequate width of keratinized attached mucosa around dental implants may lead to better soft and hard tissue stability, less plaque accumulation, and less soft tissue recession, leading to a lower incidence of peri-implant mucositis and/or peri-implantitis.

The long-term stability of pink esthetics around dental implant prostheses has been strongly correlated with adequate peri-implant soft tissue thickness (Sculean et al, 2014).

Sites with thick (> 4 mm) keratinized tissue are considered to have low risk, whereas sites with 2 to 4 mm of keratinized tissue are considered to be of medium risk. Additional soft tissue procedures may be indicated (Figure 36).

Sites with thin tissue phenotype (< 2 mm) in esthetically important areas are difficult to manage, with elevated risk of esthetic complications (Figure 37). They are at greater risk of recession of the marginal mucosa (Evans & Chen, 2008) and may frequently require adjunctive soft tissue augmentation procedures to prevent this from occurring. When performing bone augmentation procedures, an additional displacement of the mucogingival junction may also occur.

This increases the difficulty of treatment and requires a high level of clinical skill and experience to undertake these procedures with predictable outcomes.

3.6.1.4 QUALITY OF SOFT TISSUES

Adequate soft tissue management is imperative for optimal outcomes. The presence of scars, low muscle insertions, and inflammation can jeopardize healing and compromise surgical flap design and management, vascular supply, and the tissue phenotype.

Absence of scars and inflammation is the ideal situation and provides low-risk situations.

If there is no tissue inflammation but minimal scars are present, usually the soft tissues can be adequately managed during implant placement, creating a medium risk. The clinician needs to have some experience in managing these soft tissues and their potential healing deficiencies.

When scars or strong fibrous tissue attachments are present, they usually require additional staged soft tissue procedures to obtain a better tissue quality (Figure 38). These require more experience and bring additional morbidity, being classified as high risk.

The presence of acute or chronic inflammation, such as fistulas (Figure 39), increases the risk of tearing the tissue and

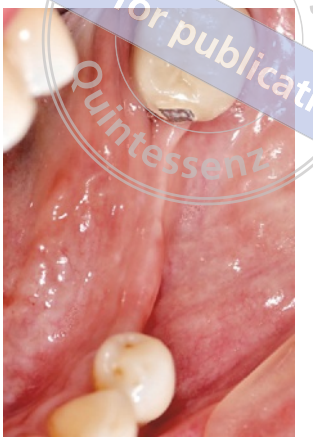


Fig 36. Thin ridge with less than 2 mm of keratinized tissue in the planned position of the implants. Adjunctive soft tissue management is required.

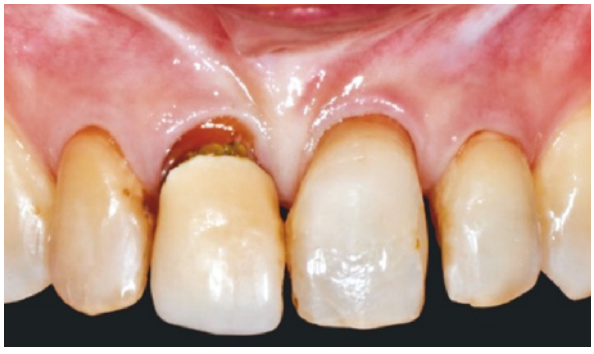


Fig 37. Thin tissue phenotype and recession around central incisors.

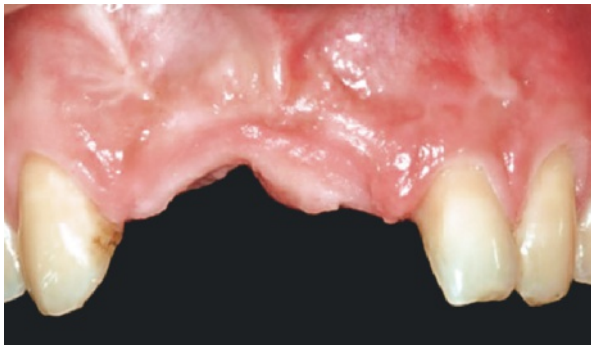


Fig 38. Multiple missing teeth in the anterior area, with soft tissue defects and scars.

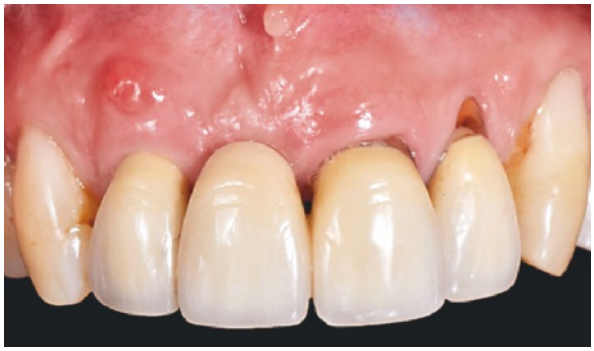


Fig 39. Inflammation on lateral incisor; recession around adjacent canine.

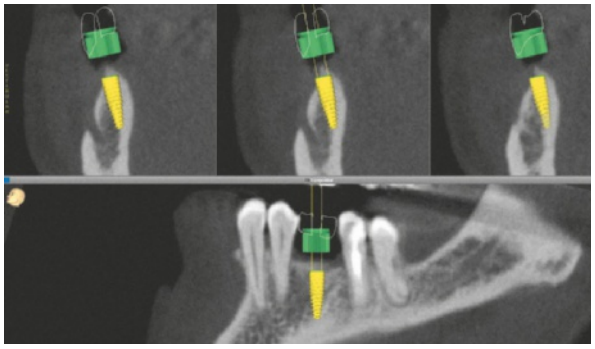


Fig 40. Virtual surgical planning of implant for mandibular premolar region. Note the proximity of planned implant to the mental foramen.

impairing healing, and are also classified as a high risk (Blanco et al, 2019).

3.6.1.5 PROXIMITY TO VITAL ANATOMICAL STRUCTURES

Any implant surgery carries a risk of involvement of nearby anatomical structures such as adjacent roots, neurovascular structures, maxillary sinus, nasal cavity, and perforation of the buccal or lingual/palatal cortical bone. Careful clinical and radiographic preoperative assessment of the bone shape and dimension, as well as the condition of the soft tissues, is required to determine the degree of risk of injuring these structures (Figure 40).

When harvesting bone or soft tissue for grafting, the anatomical risk at the donor site must also be considered. Depending on the clinical situation, the surgical requirements are more complex, and the risk may range from low to high depending on the degree of involvement and proximity to important anatomical structures (Table 5).

ITI Learning Module Anatomy with Relevance to Implant Surgery by Vivianne Chappuis.

Table 5 Surgical modifying factors: Anatomy.

Surgical modifying factors	Risk or degree of difficulty		
	Low	Medium	High
	Site factors		
Anatomy			
Bone volume – horizontal	Adequate	Deficient, but allowing simultaneous augmentation	Deficient, requiring a separate augmentation procedure prior to implant placement
Bone volume – vertical	Adequate	Small deficiency allowing implant placement Small deficiency allowing simultaneous augmentation Adequate for implant placement but requiring bone reduction	Deficient, requiring a separate vertical bone augmentation as a first step of a staged approach Deficient, requiring vertical bone augmentation simultaneously with implant placement
Keratinized tissue	Sufficient (> 4 mm)	Minimal (2–4 mm)	Insufficient (< 2 mm)
Soft tissue quality	No scars or inflammation	Presence of minimal scars/no inflammation	Presence of scars and inflammation
Proximity to vital anatomical structures	Minimal risk of involvement	Moderate risk of involvement	High risk of involvement

3.6.2 Adjacent teeth

When performing surgical procedures, special attention must be paid to the anatomical condition of tissues surrounding the adjacent teeth, especially in the esthetic zone. Even in the posterior region, the presence or absence of healthy tissues surrounding the teeth adjacent to the planned implant site can greatly influence the risk and the final outcome.

3.6.2.1 PAPILLA

The height of the papilla next to dental implants is one of the main parameters affecting the esthetic outcome. The presence or absence of the papilla is influenced by a variety of factors. Compared with natural teeth, the papillae at implant sites are reported to be significantly shorter. Surgical reconstruction of the lost interproximal papilla can be challenging

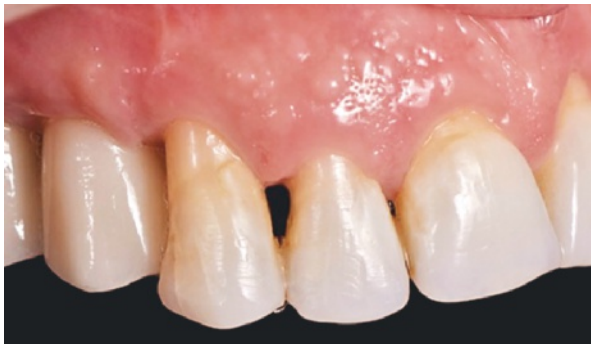


Fig 41. Lack of papilla between the canine and lateral incisor. The canine is periodontally compromised and needs to be extracted.

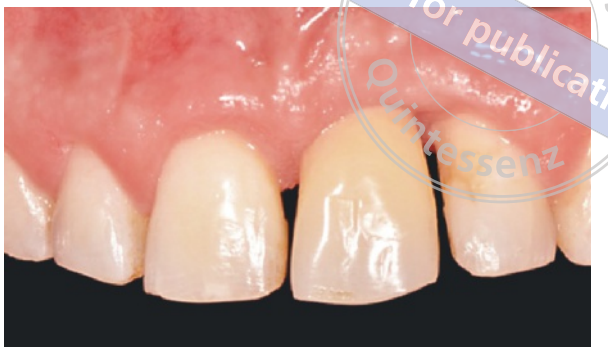


Fig 42. Clinical example of soft tissue recession on teeth adjacent to potential implant site (tooth 21)

and unpredictable. Therefore, the most predictable means to obtain a papilla is to recognize its presence and prevent its loss (Sculean et al, 2014).

The presence of papilla attached to the adjacent tooth brings a low risk. When it is deficient (Figure 41), risk can be medium, depending on the missing tooth site. Absence of a papilla characterizes a high risk.

3.6.2.2 RECESSION

The presence or absence of soft tissue recession in a tooth adjacent to a site where an implant will be placed can influence the outcomes in many aspects. Tooth loss is followed by alveolar bone loss, and in many situations this bone loss can extend to the interproximal bone attached to the adjacent tooth. Previous surgeries, periodontal disease, and trauma are the most common factors associated with recession around teeth on the facial and proximal surfaces adjacent to the missing tooth (Figure 42).

When there is a recession, surgical flaps have to be modified, and grafts over the adjacent tooth roots have to be planned in conjunction with the implant site grafts. The outcomes of grafting procedures around teeth adjacent to edentulous sites are unpredictable (Chackartchi et al, 2019) and can lead to compromised outcomes in the area being treated.

Clinicians must possess expertise in periodontal plastic surgery techniques and have experience in all the factors involved with it.

Absence of recession provides a low risk, whereas presence of recession is considered a high risk.

3.6.2.3 INTERPROXIMAL ATTACHMENT

The presence of interproximal papillae depends on the vertical position of the periodontal and crestal bone attachment of the adjacent tooth. In patients with a vertical distance between the contact point and the bone crest of ≤ 5 mm, complete papilla fill is reported to be obtained.

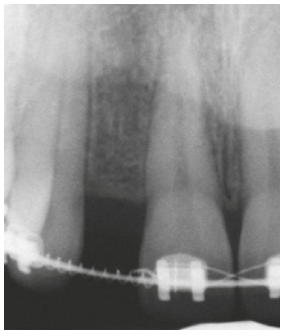


Fig 43. Periapical radiograph illustrating ideal interproximal bone attachment on teeth adjacent to implant site.

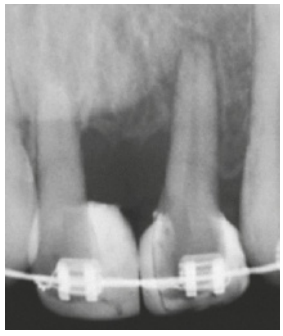


Fig 44. Periapical radiograph illustrating apically positioned bone attachment on teeth adjacent to implant site.

When the distance was > 5 mm, the presence of the papilla was reduced to a frequency of 50% (Sculean et al, 2014).

The amount of bone regenerated in a vertical dimension and the resulting papilla height are limited by the height of the periodontal attachment at the adjacent natural teeth. Preexisting attachment loss at neighboring teeth will therefore result in unfavorable papilla height. No predictable surgical techniques are presently available allowing these biologic limitations to be overcome.

Having the interproximal attachment at the level of the CEJ of the tooth adjacent to where an implant has to be placed brings a low risk for the treatment (Figure 43). The greater the distance between the CEJ and the periodontal attachment (Figure 44), the higher the risk for having adequate tissue around the future implant and restoration, increasing the risk for biologic complications (Table 6).

ITI Learning Module Surgical Assessment of the Implant Site by Wagner Duarte.

In 2009, the book SAC Classification in Implant Dentistry was published and since has received widespread acceptance in the dental profession.

The SAC Classification provides an evidence-based, objective framework for the assessment of the potential difficulty, complexity and risk of an implant related treatment for a given clinical situation and serves as a guide for clinicians in both patient selection and treatment planning.

From the book's initial release, clinical techniques, materials, and technology have continued to evolve and, in early 2017, the ITI recognized that there was a need to review the SAC Classification.

The fully revised 2nd edition of the SAC Classification in Implant Dentistry has been updated to ensure consistency with contemporary implant practice and gives an even more detailed and comprehensive overview of the risks in implant dentistry and the practical application of the SAC Classification, illustrated by new clinical case reports.

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