France Lambert
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International Team for Implantology

Immediate Implant Placement and Loading

Single or Multiple Teeth Requiring Replacement

Volume 14

ITI Treatment Guide

EDITORS
Daniel Wismeijer
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comprehensive quality education
and innovative research to the
benefit of the patient."

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Preface

The advantages of immediate implant placement and loading protocols are well documented and can be considered a desirable treatment approach if certain conditions are fulfilled.

A considerable body of literature supporting the use of immediate implant placement and loading protocols in partially edentulous patients has accumulated over the last two decades. However, a number of factors and procedures such as type of surgery, alveolar ridge preservation, and type of graft, among others, can make the clinical decisions involved challenging.

Referring to evidence-based methods, this volume of the ITI Treatment Guide series aims to provide a comprehensive overview of immediate implant placement and loading protocols for replacement of single or multiple teeth requiring extraction. It highlights the importance of patient and site selection in combination with comprehensive treatment planning and provides the reader with a risk-assessment table to aid in decision-making. The reader will also find a description of all key aspects of both surgical and loading procedures, providing clinical protocols for predictable treatment outcomes.

Step-by-step clinical cases performed by experts in the field underline the importance of careful patient selection in order to achieve successful outcomes, while also reducing patient treatment time. Overall, Volume 14 of the ITI Treatment Guide series will inform and support clinicians when faced with challenging cases of single and multiple tooth replacement.

D. Wismeijer S. Barter N. Donos

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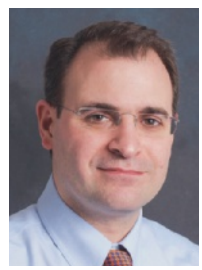

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Introduction

A. Hamilton, F. Lambert

Once a tooth is indicated for extraction and immediate replacement with a dental implant, one of the first and most important clinical decisions to make is to select an appropriate protocol for implant placement and loading. The success of this protocol is determined by four main parameters: biological, prosthetic, and esthetic outcomes, as well as patient satisfaction (as per patient-reported outcome metrics). The selected protocol should combine the maximally predictable short- and long-term outcomes with the lowest surgical morbidity and highest efficiency (Buser and coworkers 2017a).

Our continuously better understanding of the biology of immediate placement has had a significant impact on the evolution of immediate placement and loading protocols and procedures. The advantages of immediate placement are well documented; they include shorter overall treatment times, limitation to a single surgical session, and maximum availability of potential bone volume (since the extraction socket will not yet have undergone the inevitable post-extraction resorption) (Hämmerle and coworkers 2004; Chen and Buser 2008). Immediate implant placement and loading is a desirable protocol—provided that the appropriate clinical indications are present.

However, several limitations have been reported for this approach. Immediate placement is made more complicated by the morphology of the socket and the surrounding alveolar bone. Achieving the ideal three-dimensional position of the implant while obtaining primary stability can be a challenge. Immediate placement does not limit the alveolar bone resorption associated with tooth extraction (Araújo and coworkers 2005). Unless addressed by proper patient selection and adjunctive regenerative procedures, this bone resorption may lead to midfacial recession and esthetic compromises (Chen and Buser 2014).

Considerable research into immediate placement and immediate loading in partially edentulous patients has been published over the last two decades. Overall, the literature reports this to be a predictable treatment approach, with implant survival rates comparable to delayed protocols using contemporary treatment approaches (Gallucci and coworkers 2018). However, the diversity of surgical and prosthetic techniques in terms of adjunctive procedures and factors can make clinical decisions difficult.

These adjunctive factors include:

- Type of surgery (flapless versus open-flap procedures)
- Alveolar ridge preservation (socket grafting versus no graft)
- Type of graft (*autologous, allograft, or xenograft*)
- Use of connective tissue graft (CT) for soft tissue augmentation
- Simultaneous connection of a provisional prosthesis (immediate loading)

There seems to be a trend for studies of immediate (type 1A) implant placement that use adjunctive regenerative procedures to minimize and compensate for resorption of the facial tissues (flapless, bone graft, and CT graft) to exhibit less variability in terms of esthetic outcomes (Chen and Buser 2008; Seyssens and coworkers 2021)

The focus of the present Volume 14 of the ITI Treatment series is on modern treatment protocols for immediate implant placement following the flapless extraction of a tooth. The reduced surgical trauma and morbidity associated with this approach offer distinct biological advantages and provide greater patient benefits than more invasive approaches.

This volume therefore aims to provide a comprehensive overview of immediate implant placement and loading protocols for the replacement of single teeth requiring extraction. The current literature on immediate implant placement and immediate loading is outlined to provide the biological understanding that underpins these concepts, together with a review of the success of immediate tooth-replacement protocols (Chapter 2).

The main objective of this volume is to highlight the importance of patient and site selection in conjunction with comprehensive treatment planning, and to provide the reader with a risk assessment tool that will aid in decision-making (Chapter 3).

Even if the sites for immediate implant placement and loading are carefully selected, these interventions are technically complex, with many variations in proposed treatment protocols. The second objective of this volume is therefore to describe the key aspects of both the surgical and loading procedures, in order to provide protocols that optimize the final outcome (Chapter 4).

This volume also provides step-by-step reports of clinical cases performed by experts in the field, exploring a range of indications and applications for immediate implant placement and loading protocols (Chapter 5).

The final chapter discusses typical complications associated with immediate implants and provides recommendations on how to prevent them (Chapter 6).

2 Evolution of Immediate Implant Placement and Loading

A. Hamilton, F. Lambert, M. Baćević, M. Araújo,
S. Chen, G. Gallucci

2.1 Evolution of Implant Placement Protocols

The original protocol for implant placement required a healed alveolar ridge and involved a two-stage surgical procedure (Schroeder and coworkers 1976; Brånemark and coworkers 1977). Even though the Tübingen immediate implant, which allowed implant placement into fresh extraction sockets, was introduced soon thereafter (Schulte and coworkers 1978), immediate implants presented a more challenging option to traditional (delayed) implants for decades to follow. Techniques based on the principles of guided bone regeneration (GBR) (Dahlin and coworkers 1988; Dahlin and coworkers 1989) were also investigated at that time and applied to peri-implant extraction defects of immediate implants in combination with open-flap procedures (Lazzara 1989; Becker and Becker 1990; Lang and coworkers 1994).

Early on, studies had shown that implants placed into fresh extraction sockets could successfully achieve osseointegration (Barzilay and coworkers 1988; Barzilay and coworkers 1991; Paolantonio and coworkers 2001), but higher implant failure rates were also reported (Schwartz-Arad and Chaushu 1997, Mayfield 1999). By the late 1990s, new studies had emerged to demonstrate that not only immediate implant placement was possible but also immediate loading (of the implants) (Wöhrle 1998). However, initial clinical results with immediate implants or immediate loading were not always satisfactory, particularly in regard to esthetic outcomes (Chen and coworkers 2004).

The introduction of implants with moderately rough surfaces provided a better understanding of the bone/implant interface and healing processes, as well as occlusion and proper prosthetic design. Along with the improvement of implant design, immediately placed and loaded implants slowly gained acceptance among the scientific community and among clinicians (Avila and coworkers 2007). Following the accumulation of an extensive body of evidence, both immediate implant placement and immediate loading have become accepted clinical procedures within the indicated conditions.

A widely adopted classification of 4 categories for the timing of implant placement after tooth extraction (type 1 to type 4) was first established at the 3rd ITI Consensus Conference (Hämmerle and coworkers 2004) and further modified in Vol. 3 of the ITI Treatment Guide series (Chen and Buser 2008), which classified immediate implant placement following tooth extraction as type 1 (Fig 1).

The main benefit of type 1 (immediate) implant placement lies in the reduced number of surgical procedures, shorter overall treatment times, reduced recovery times, and—in certain circumstances—the ability to immediately restore the implant, leading to high patient satisfaction as well as positive effects regarding the maintenance of the peri-implant softtissue architecture.

A biological understanding of immediate implant placement relies on the biology of socket healing. Post-extraction socket healing is a biological process where several processes develop continuously, despite being arbitrarily assigned to distinct phases, namely: hemostasis and coagulation, inflammatory, proliferative, and modeling and remodeling phases (de Sousa Gomes and coworkers 2019).

Immediately after tooth extraction, the socket is filled with blood; a blood clot is formed soon thereafter. The wound starts to attract inflammatory cells that infiltrate the clot and embark on phagocytosis—removing bacteria and clot structures—as well as on the production of different growth factors. At the same time, new blood vessels start to sprout, and loosely organized granulation tissue intensely infiltrated by inflammatory cells and fibroblasts replaces the initial blood clot, which undergoes coagulative necrosis (Cardaropoli and coworkers 2003).

The granulation tissue is progressively replaced by immature connective tissue (provisional matrix) rich in cells and collagen fibers organized in a woven pattern. Subsequently, undiffer-

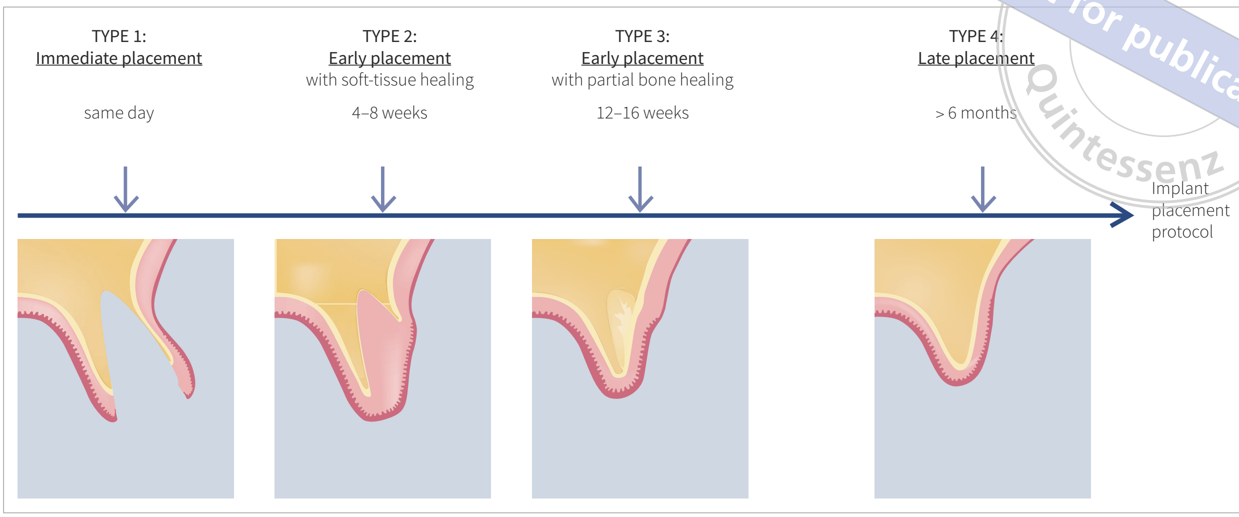
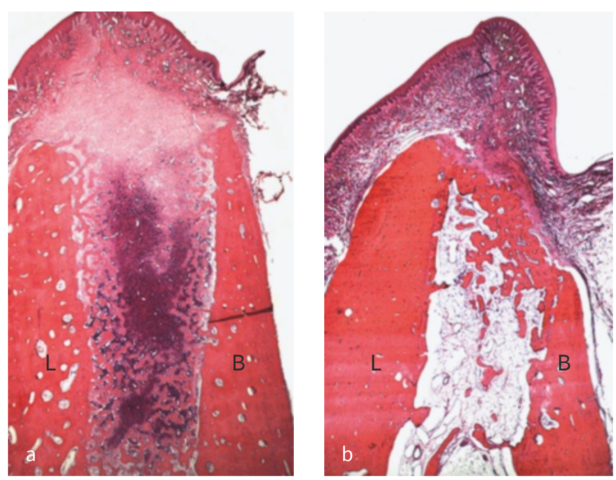


Fig 1 Timing of implant placement.

entiated mesenchymal cells penetrate the fibrous tissue and start differentiating into bone-forming cells, which promote the mineralization of the organic matrix to form the so-called woven bone. Woven bone progressively becomes replaced by mature lamellar bone tissue/bone marrow, and the alveolar ridge, at the socket wall, undergoes dimensional alterations (Figs 2a-b) (Araújo and Lindhe 2005).

Use this QR code to view a computer-animated 3D film on osseointegration.

Use this QR code to view a 3D animation about socket healing.



Figs 2a-b Macroscopic histological images demonstrating the bone modelling 1 week (a) and 8 weeks (b) following tooth extraction demonstrating resorption of the thin facial bone visible on the right side of the images.

Most dimensional changes following tooth extraction occur in the first three months after tooth removal (Schropp and coworkers 2003) and continue as long as the modeling phase takes place, although with lesser intensity. Post-extraction dimensional alterations seem to be related to several factors, such as the individual healing properties of a patient, anatomical or pathological site characteristics, and the extent of surgical trauma and tissue destruction induced during the extraction procedure (Araújo and coworkers 2015).

Figs 3a-c Resorptive changes after tooth extraction occur independently of the timing of implant placement and immediate implants fail to prevent them. Baseline (a), 4 weeks (b), and 12 weeks (c) after tooth extraction demonstrating resorption of the thin facial bone visible on the right side of the images adjacent to the immediately placed implants.

Although all these factors may vary, a mean hardtissue reduction of 3.8 mm (29–63%) in width and 1.24 mm (11–22%) in height during the first six months of healing was reported in a systematic review evaluating post-extraction hard and soft tissue dimensional changes (Tan and coworkers 2012).

The following resorption patterns have been observed:

- Greater resorption in width than height (Johnson 1969)
- The mandibular bone resorbs faster than the maxillary bone (Atwood 1971)
- The molar area endures more resorption than the frontal area (Pietrokovski and Massler 1967)
- Greater vertical changes occur in multiple adjacent extraction sites compared with single-tooth extraction sites (Lam 1960)
- The buccal plate is resorbed first (Cawood and Howell 1988)

Thin buccal walls, intrinsically present in the anterior maxilla, are especially prone to resorption. Araújo and coworkers (2005) hypothesized that the coronal part of buccal bone plate was often made only of bundle bone, which is a part of the periodontium and thus a tooth-dependent structure. Removing a tooth renders this bone useless, and its resorption is a natural consequence. Studies have shown that thin facial bone (< 1 mm) at the socket is likely to resorb three times more in the apicocoronal plane than thick facial bone (≥ 1 mm) when immediate implants are placed (Ferrus and coworkers 2010).

Additionally, damaged facial bone with fenestrations or any kind of dehiscence in the bone walls will make the bone weaker and more prone to resorption (Kan and coworkers 2007), while sites presenting thick buccal bone exhibit less dimensional changes of the alveolar ridge after tooth extraction (Chappuis and coworkers 2013; Chappuis and coworkers 2015). Other risk factors include a thin periodontal phenotype (Evans and Chen 2008; Cordaro and coworkers 2009) and inadvertent facial malposition of the implant within the socket at placement (Chen and coworkers 2007; Evans and Chen 2008).

Once it had been demonstrated that the osseointegration of implants placed in fresh extraction sockets was a predictable outcome (Chen and coworkers 2004) and took place irrespective of the gap between the implant surface and the bony socket walls, studies proceeded to investigate the physiological process of socket healing combined with immediate implant placement. Initially, proponents of immediate implants as a novel therapeutic concept argued that it may counteract post-extraction buccal-bone resorption, benefiting from the supporting role of the tooth and hence providing better esthetic outcomes (Lazzara 1989; Denissen and coworkers 1993). However, subsequent studies yielded contradictory results, namely that resorptive changes after tooth extraction occur independently of the timing of implant placement and that immediate implants fail to prevent them (Botticelli and coworkers 2004; Araújo and coworkers 2005; Chen and coworkers 2007) (Figs 3a-c) (Araújo and coworkers 2006).

These findings led researchers to combine immediate implants with alveolar ridge preservation procedures that involve grafting the peri-implant socket defect with bone substitutes to limit post-extraction remodeling and to achieve a better long-term functional and esthetic outcomes of implant restorations (Chen and coworkers 2004).

Most evidence on immediate implants involves maxillary anterior teeth (Zhou and coworkers 2021), where esthetic outcomes play a key role for success. One of the early limitations of immediate placement was the use of coronally advanced full-thickness mucoperiosteal flaps to achieve submerged healing with or without concomitant bone grafting. Implants were also often placed in compromised sockets with thin or absent buccal plates. Although such procedures produce successful outcomes in terms of osseointegration and implant survival, esthetic limitations and—most commonly—midfacial recession were frequently reported with 20–30% of immediate implants at risk of midfacial mucosal recession of 1 mm or more (Chen and Buser 2009; Chen and Buser 2014).

Various alveolar-ridge preservation techniques and protocols have been described, aimed at minimizing dimensional changes and esthetic challenges. These include particulate bone grafts or substitutes and socket-sealing techniques using connective tissue grafts, a barrier membrane, or plugs. Among other opinions, the 2019 European Workshop in Periodontology Consensus statements indicated that alveolar ridge preservation via socket grafting limits horizontal and vertical post-extraction bone resorption, compared to tooth extraction alone (Avila-Ortiz and coworkers 2019; Tonetti and coworkers 2019). The same workgroup also concluded that socket grafting in conjunction with immediate implant placement is an integral component of the procedure in most cases.

Current evidence seems to indicate a trend toward better outcomes when implants are placed immediately in a flapless approach combined with socket grafting, plus connective-tissue grafting in patients with a thin soft tissue phenotype (Seyssens and coworkers 2020; Seyssens and coworkers 2021).

2.2 Evolution of Implant Loading Protocols

The biological process of osseointegration of a dental implant follows a pattern similar to that of bone fracture healing.

One prerequisite for direct bone fracture healing is wound stabilization and rigid fixation, with excessive loads at the wound interface leading to delayed healing or non-union (Marsell and Einhorn 2011). With dental implants, this stabilization is achieved through the insertion of an endosseous implant with a diameter slightly larger than that of the osteotomy. This provides primary stability, which is a requirement for osseointegration and long-term implant success.

The original loading protocols for endosseous implants proposed by Per-Ingvar Brånemark and André Schroeder required an undisturbed healing time of three to four months prior to loading (Schroeder and coworkers 1976; Adell and coworkers 1981; Buser and coworkers 2000). The protocols were proposed based on their understanding of osseointegration at the time, which involved a necrotic border zone around the implant due to the surgical trauma of the osteotomy preparation. It was suggested that the necrosis and replacement of the bone adjacent to the implant was inevitable, and it was recommended to leave the implant undisturbed throughout this process until osseointegration had occurred, as minor movements would inhibit osteogenesis and jeopardize osseointegration (Albrektsson and coworkers 1981; Schroeder and coworkers 1981).

Over the next few decades, our understanding of the physiology of the osseointegration process evolved, and clinical studies soon emerged to challenge this paradigm by demonstrating that implants in fully edentulous sites could be immediately loaded when four implants were placed with cross-arch splinting (Ledermann 1979; Babbush and coworkers 1986).

The concept of immediate loading continued to evolve (Schnitman and coworkers 1990). By the late 1990s, interest had turned to a challenging clinical scenario in which an immediate provisional prosthesis was connected to an implant placed in a fresh extraction socket in the anterior maxilla (Wöhrle 1998). Implant technology had improved to the point where the healing period prior to loading could be reduced, with immediate loading considered predictable given a proper indication, with results comparable to conventional loading protocols (Cochran and coworkers 2004; Gallucci and coworkers 2014; Gallucci and coworkers 2018).

This was underpinned by advances in two areas:

- A research focus on the reduction of surgical trauma and subsequent necrosis to the surrounding bone during osteotomy preparation and insertion of a dental implant (Eriksson and Albrektsson 1983; Möhlhenrich and coworkers 2015; Bernabeu-Mira and coworkers 2021)
- Research on the regeneration of bone adjacent to the implant during the osseointegration process, where surface technology was identified as a key component (Salvi and coworkers 2015; Bosshardt and coworkers 2017).

Osseointegration is now recognized as a dynamic process in which the resorption of damaged bone and the apposition of new bone through regeneration occur simultaneously. This follows current mechanobiological models of bone fracture healing, which recognizes that the physiologically complex healing process involves both biological and mechanical aspects (Ghiasi and coworkers 2017).

It is generally established that mechanical stability throughout the osseointegration process is required for short- and long-term clinical success (Listgarten and coworkers 1991; Albrektsson and Zarb 1993). Mechanical stability is required to limit micromovements from direct or indirect forces being applied to the implant that would result in fibrous encapsulation and implant failure. As osseointegration occurs, the initial primary mechanical stability—by which the implant resists movement from loading in the initial healing phase—is substituted for secondary stability (Fig 4) where the newly regenerated bone has matured to the point where it can contribute to the stability of the implant under loading conditions (Bosshardt and coworkers 2017).

With this transition from primary to secondary implant stability, a dip in the overall mechanical stability of the implant occurs. This constitutes a risk factor for implant failure if excessive loads are applied at this point in the healing process (Raghavendra and coworkers 2005; Oates and coworkers 2007; Lang and coworkers 2011).

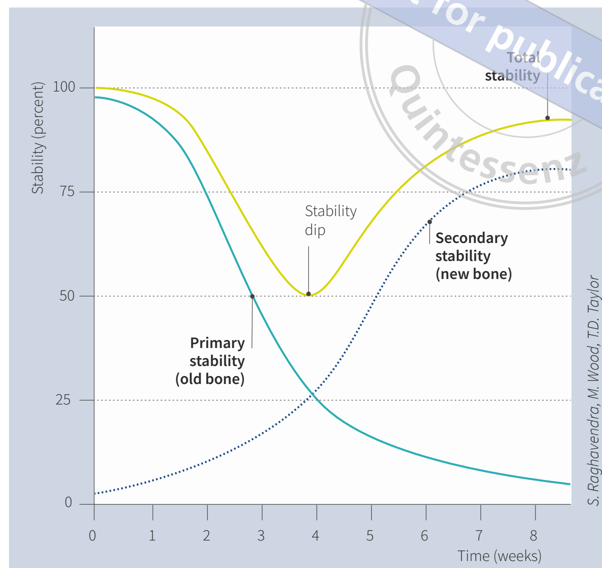


Fig 4 Illustration of the gradual rise in secondary stability as the primary stability Is reduced. The rate of increase in secondary stability can be influenced by the implant's surface characteristics, surgical trauma, and the biological capacity of the patient.

Immediate loading of dental implants may present some advantages, mainly in that it eliminates the need for removable transitional appliances, which are often inconvenient for the patient to wear and can be deleterious to the underlying surgical site if the transitional appliance is tissue-supported. An immediate implant-supported provisional restoration also provides an opportunity to provide prosthetically guided soft tissue healing, which can assist in maintaining the pre-extraction soft tissue architecture. While these objectives can also be achieved with alternatives (bonded bridges, custom healing abutments), immediate provisionalization of immediately placed dental implants provides the most efficient pathway.

Contemporary protocols for immediate implant placement recognize that the preservation of the soft tissue contours and architecture at the time of extraction can provide predictable results in the context of prosthetically guided soft tissue healing (Schubert and coworkers 2019). An immediately loaded provisional or custom healing abutment with an appropriately shaped emergence profile will support the marginal soft tissue while containing the grafting material and blood clot and minimizing contamination by saliva. With biocompatible materials, soft tissue adhesion can also promote soft tissue stability and help minimize post-extraction ridge alterations.

2.3 Current Concepts and Definitions of Implant Placement and Loading Protocols

The current classification of implant placement and loading protocols was defined in a 2018 systematic review by Gallucci and coworkers and adopted by the 2018 ITI Consensus Conference. In this new classification, the relationship between these two treatment concepts is combined into one classification system (Table 1) with the relative timelines illustrated in Figure 5. This approach recognizes that these two events occur for every implant that is placed and that they are not independent of each other, but rather co-dependent variables that influence success and outcomes. Twelve different combinations of implant placement and loading were described, as follows:

Type 1A: Immediate placement + immediate restoration/loading
Type 1B: Immediate placement + early loading
Type 1C: Immediate placement + conventional loading
Type 2A: Early placement with soft tissue healing + immediate restoration/loading
Type 2B: Early placement with soft tissue healing + early loading
Type 2C: Early placement with soft tissue healing + conventional loading
Type 3A: Early placement with partial bone healing + immediate restoration/loading
Type 3B: Early placement with partial bone healing + early loading
Type 3C: Early placement with partial bone healing + conventional loading
Type 4A: Late placement + immediate restoration/loading
Type 4B: Late placement + early loading
Type 4C: Late placement + conventional loading.

In this classification, previous definitions of the timing of implant placement and loading were adopted from previous ITI Consensus Conferences, as follows:

IMPLANT PLACEMENT PROTOCOLS

- ***Late implant placement:*** Dental implants are placed after completely bone healing, more than six months after tooth extraction
- ***Early implant placement:*** Dental implants are placed with soft tissue healing or with partial bone healing, four to eight weeks or twelve to sixteen weeks after tooth extraction
- ***Immediate implant placement:*** Dental implants are placed in the fresh socket on the same day of tooth extraction

(Chen and Buser 2009; Chen and coworkers 2004; Hämmerle and coworkers 2004).

Table 1 Classification combining implant placement and loading time

		Loading protocol		
		Immediate restoration/loading (type A)	Early loading (type B)	Conventional loading (type C)
Implant placement protocol	Immediate placement (type 1)	Type 1A	Type 1B	Type 1C
	Early placement (type 2-3)	Type 2-3A	Type 2-3B	Type 2-3C
	Late placement (type 4)	Type 4A	Type 4B	Type 4C

Gallucci, Hamilton, Zhou, Buser and Chen 2018. 6th ITI Consensus Report. Group 2. Article 2

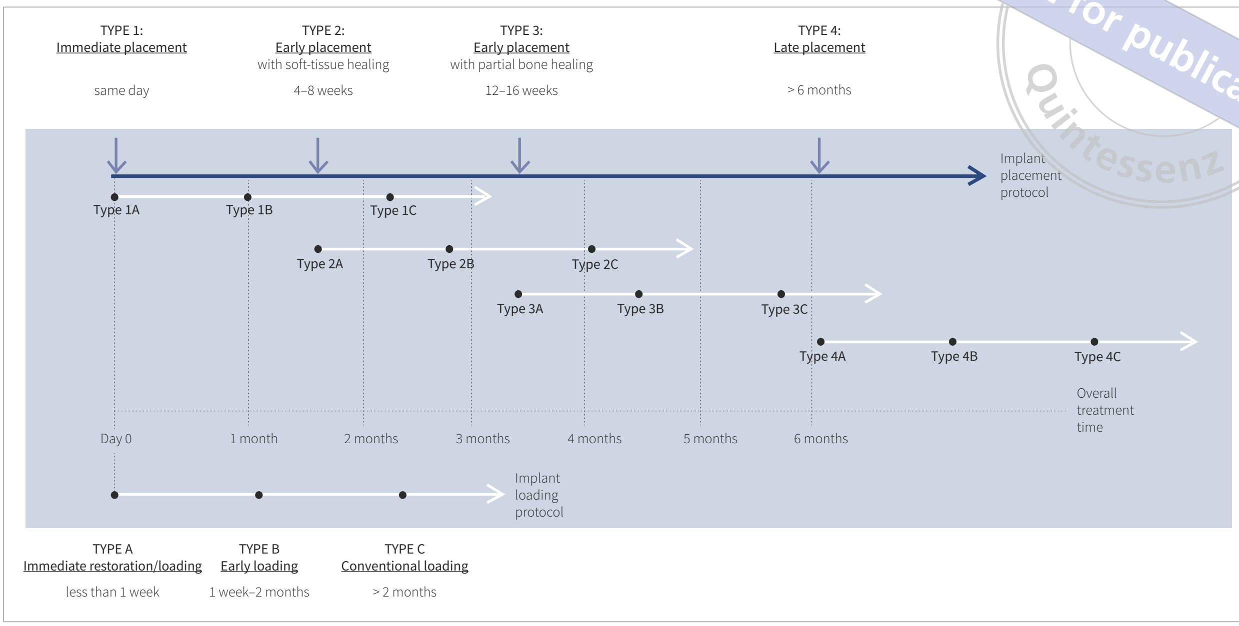


Fig 5 Timeline based on the definitions of implant placement protocols and implant loading protocols (after Zhou and coworkers 2021).

IMPLANT LOADING PROTOCOLS

- ***Conventional loading:*** Dental implants are allowed a healing period of more than two months after implant placement with no connection to the prosthesis.
- ***Early loading:*** Dental implants are connected to the prosthesis between one week and two months after implant placement.
- ***Immediate loading:*** Dental implants are connected to the prosthesis within one week after implant placement.

This is in line with the publications of the previous ITI Consensus Conferences (Benic and coworkers 2014; Chiapasco 2004; Cochran and coworkers 2004; Gallucci and coworkers 2014; Gallucci and coworkers 2009; Ganeles and Wismeijer 2004; Grutter and Belser 2009; Morton and coworkers 2004; Papaspyridakos and coworkers 2014; Roccuzzo and coworkers 2009; Schimmel and coworkers 2014; Schrott and coworkers 2014; Weber and coworkers 2009).

Thus, for immediate implant placement, three subcategories were listed:

- ***Type 1A:*** Immediate placement + immediate restoration/loading
- ***Type 1B:*** Immediate placement + early loading
- ***Type 1C:*** Immediate placement + conventional loading

The analysis of the survival rates of each of these treatment protocols based on this new classification follows in the next section.

2.4 Proceedings of the 6th ITI Consensus Conference

2.4.1 Consensus Statements Regarding Implant Placement and Loading Protocols

1. The newly proposed classification assessing both the timing of implant placement and loading combinations allows for comprehensive treatment selection.
2.
   a. Type 1A (immediate placement + immediate restoration) is a clinically documented protocol. The survival rate was 98% (median: 100%; range: 87–100%).
   b. Type 1B (immediate placement + early loading) is a clinically documented protocol. The survival rate was 98% (median: 100%; range; 93–100%).
   c. Type 1C (immediate placement + conventional loading) is a scientifically and clinically valid protocol. The survival rate was 96% (median: 99%; range: 91–100%).
3.
   a. Type 2-3A (early placement + immediate restoration/loading) presents clinically insufficient documentation.
   b. Type 2-3B (early placement + early loading) presents clinically insufficient documentation.
   c. Type 2-3C (early placement + conventional loading) is a scientifically and clinically valid protocol. The survival rate was 96% (median: 96%; range: 91–100%).
4.
   a. Type 4A (late placement + immediate restoration/loading) is a clinically documented protocol. The survival rate was 98% (median: 99%; range 83–100%).
   b. Type 4B (late placement + early loading) is a scientifically and clinically valid protocol. The survival rate was 98% (median: 99%; range: 97–100%).
   c. Type 4C (late placement + conventional loading) is a scientifically and clinically valid protocol. The survival rate was 98% (median: 100%; range: 95–100%).
5. When considering placement/loading protocols, there are factors that can prevent achievement of the intended treatment. These factors include:
   a. Patient-related factors
   b. Lack of primary stability
   c. The need for bone augmentation

2.4.2 Clinical Recommendations Regarding Implant Placement and Loading Protocols

Immediate implant placement and immediate restoration/loading is considered a complex surgical and prosthodontic procedure. Clinicians performing this procedure need to have sufficient training, experience, and clinical skill to be able to undertake the necessary diagnostic procedures and to perform the treatment.

The ITI recommends that the type 1A protocol should only be considered if there are demonstrable patient-centered advantages, such as esthetic requirements or a clinical indication to reduce surgical morbidity (Morton and coworkers 2018). For example, there seems to be little advantage in connecting an immediate provisional restoration to an immediately placed implant in a first-molar site. Although it has been clinically documented (Atieh and coworkers 2010), there is little patient-centered advantage to this approach over conventional placement and loading protocols.

The following clinical conditions are recommended for the type 1A protocol (Morton and coworkers 2014; Morton and coworkers 2018):

- ***Intact socket bone walls.*** In particular, the status of the facial bone wall is critical to esthetic outcomes. Diagnostic CBCT scans are often able to evaluate the condition of the facial socket wall; however, it can often be obscured by metal artifacts from a post within a root canal. The facial bone wall can also be damaged as a result of the extraction procedure. Therefore, the facial bone should be definitively evaluated following tooth extraction.

- ***Facial bone at least 1 mm thick.*** Clinical studies have demonstrated that thin facial bone (< 1 mm) is prone to significant vertical crestal resorption (Chen and coworkers 2007; Ferrus and coworkers 2010; Sanz and coworkers 2017). If this resorption is extensive, bone grafts placed into the facial peri-implant defect may not be fully contained within the bone walls and are therefore prone to resorption. This may result in incomplete bone fill within the peri-implant defect (van Steenberghe and coworkers 2000; Chen and coworkers 2007; Juodzbalys and Wang 2007), exposure of the rough surface of the implant crestally, and recession of the midfacial peri-implant mucosa.
- ***Thick soft tissue phenotype.*** Sites with a thin soft tissue phenotype run a greater risk of recession of the midfacial mucosa, which may have adverse implications for final esthetic outcomes (Evans and Chen 2008; Cordaro and coworkers 2009). Cases with a thin soft tissue phenotype should be avoided unless additional interventions promote thickening of the facial gingiva. Such additional interventions may include intentional decoronation and submergence of the root to promote gingival overgrowth, soft tissue thickening (Langer 1994) incorporating connective tissue grafts into the soft tissue marginal area on the facial aspect of the socket (Kan and coworkers 2005; Chen and coworkers 2009; Kan and coworkers 2009), or grafting of the supracrestal region with small-particle bone substitutes that promote soft tissue thickening (Chu and coworkers 2012; Chu and coworkers 2015).
- ***No acute infection at the site.*** Sites with acute infection should not be considered for the type 1A protocol as there is likely to be damage to one or more socket walls, and the inflammation of the soft tissues may lead to significant recession.
- ***Sufficient bone volume apical and lingual to the socket.*** This is to allow the implant to be placed with primary stability. This is an essential requirement to ensure that the implant can then be connected to a provisional restoration. CBCT scans provide essential information establishing this requirement.
- ***Resistance to rotational torque.*** The implant should resist the torque that is likely to be applied to the abutment screw of the provisional restoration. This largely depends upon the recommendations of the implant manufacturer, which with current implant systems should be in the range of 25-40 Ncm or ISQ value > 70.
- ***Occlusal scheme that protects the provisional restoration*** during function. Cases should therefore be selected where direct occlusal contact between the provisional restoration and opposing dentition can be avoided.
- ***Patient compliance.*** The patient should be prepared to follow postoperative instructions. The critical factor is to avoid direct masticatory function on the provisional prosthesis.

2.5 Proceedings of the 7th ITI Consensus Conference

In the 7th ITI Consensus Conference in 2023, the literature specifically on type 1A immediate implant placement and immediate loading in the anterior maxilla (teeth 15 to 25) was assessed and new consensus statements as well as clinical recommendations were made as an update to those from the 6th ITI Consensus Conference, in which all implant placement and loading protocols were assessed.

2.5.1 Consensus Statements Regarding Type 1A Immediate Implant Placement and Immediate Loading

The following consensus statements were developed from the two systematic reviews that assessed selection criteria and implant survival (Hamilton and coworkers 2023) and clinical performance (Wittneben and coworkers 2023) of immediately placed and immediately loaded dental implants (type 1A) for single-tooth replacement in the anterior maxilla (teeth 15 to 25) (region of esthetic significance). All implants included in the two reviews exhibited a minimum of 12 months of follow-up.

SYSTEMATIC REVIEW PAPER 1

***Hamilton** A, Gonzaga L, Amorim K, Wittneben JG, Martig L, Morton D, et al. Selection criteria for immediate implant placement and immediate loading for single tooth replacement in the maxillary esthetic zone: a systematic review and meta-analysis. Clin Oral Implants Res. 2023; 34 [forthcoming].*

Preamble

The following consensus statements are based on a systematic review that assessed implant survival with type 1A (immediate implant placement and immediate restoration/loading) protocol for implant replacement of single teeth in the anterior maxilla (teeth 15 to 25), with a minimum of 12 months of follow-up. The review also assessed the reported patient and site-specific selection criteria that may influence survival outcomes. The review is based on data from 43 prospective (11 randomized controlled trials, RCTs, and 6 clinical controlled trials, CCTs) and 25 retrospective studies with a total of 2,531 implants with a mean follow-up of 2.6 years.

Consensus statements

1. The type 1A protocol for replacement of a single tooth in the anterior maxilla (teeth 15 to 25) is predictable with high implant survival rates. This is based on studies with highly selective populations, with favorable patient and site-specific characteristics. When failures occur, the majority are within the first 6 months of implant placement. This statement is supported by 43 prospective (including data from 11 RCTs, 6 CCTs) and 25 retrospective studies.
2. Multiple patient and site-specific factors are relevant in the selection and completion of a type 1A protocol for the replacement of a single tooth in the anterior maxilla (teeth 15 to 25 FDI). These include:
   a. General factors
      - Medical status (63 studies)
      - Periodontal disease (54 studies)
      - Occlusal scheme (57 studies)
      - Parafunction (26 studies)
   b. Site-specific factors
      - Facial bone wall (60 studies)
      - Endodontic infection (42 studies)
      - Bone for anchorage (37 studies)
      - Soft tissue quality (25 studies)
      - Gingival margin position (22 studies)
   c. Treatment factors
      - Mucoperiosteal flap (63 studies)
      - Damage during tooth extraction (59 studies)
      - Gap between the facial bone and implant (56 studies)
      - Primary implant stability (42 studies)

3. The type 1A protocol may not be able to be completed in all selected sites due to intraoperative procedural events mostly related to the extraction of the tooth or lack of primary implant stability. This statement is supported by 23 prospective studies (including data from 11 RCTs and 2 CCTs).
4. A chronic periapical infection associated with the tooth to be extracted is not a contraindication for the type 1A protocol provided there is sufficient bone to achieve primary implant stability. This statement is supported by 29 prospective (including data from 9 RCTs and 3 CCTs) and 13 retrospective studies.
5. With regards to implant position, the presence of at least a 2 mm gap between the implant and the facial bone increases implant survival when the type 1A protocol is utilized. This statement is supported by 13 prospective (including data from 5 RCTs and 2 CCTs) and 7 retrospective studies.

SYSTEMATIC REVIEW PAPER 2

***Wittneben** JG, Molinero-Mourelle P, Hamilton A, Alnasser M, Obermaier B, Morton D, et al. Clinical performance of immediately loaded single implants in the esthetic zone. A systematic review and meta-analysis. Clin Oral Implants Res. 2023; 34 [forthcoming].*

Preamble

The following consensus statements are based on a systematic review that assessed the clinical performance of dental implants used according to the type 1A (immediate implant placement and immediate restoration/loading) protocol for replacement of single teeth in the esthetic zone (anterior maxilla, teeth 15 to 25).

The statements are based on up to 38 prospective (including 10 RCTs) and 25 retrospective studies with a follow-up of being 12 and 96 months.

Consensus statements

1. The type 1A protocol, when utilized in the esthetic zone, is a clinically viable treatment option. However surgical, technical, and biological complications can occur. This statement is supported by 63 studies (10 randomized controlled trials, 28 prospective and 25 retrospective studies) with a follow-up ranging from 12 to 96 months. Surgical (mean per year, 5.86%; 38 clinical studies) technical (mean, 3.27%; 25 clinical studies) and biological (mean, 2.18%; 29 clinical studies) complications may occur.
2. For the type 1A protocol, survival is not influenced by the type of implant (bone level versus parallel walled versus tapered design). This statement is supported by 63 studies (10 randomized controlled trials, 28 prospective and 25 retrospective studies) with a follow-up ranging from 12 to 96 months.
3. For the type 1A protocol there was an increase in PES (pink esthetic score) when the space between the implant and the facial bone of the residual socket was grafted with autologous bone or bone substitute. This statement is supported by 35 studies (7 randomized controlled trials, 12 prospective and 16 retrospective studies) with a follow-up ranging from 12 to 96 months.
4. For the type 1A protocol, the flapless approach provides good esthetic outcomes (papilla height, PES, and WES). This statement is supported by 11 clinical studies for papilla height, 31 clinical studies for PES and 16 clinical studies for WES.
5. For the type 1A protocol, differences in survival are not influenced by type of retention (screw- or cement-retained) when focusing on the final restoration. This statement is supported by 29 clinical studies.

2.5.2 Clinical Recommendations Regarding Type 1A Immediate Implant Placement and Immediate Loading

The replacement of a single tooth in the anterior maxilla (teeth 15 to 25 FDI) with the type 1A protocol is a complex procedure with high patient-centered benefits. It should be considered as the treatment of choice when ideal conditions are present. Ideal site conditions include:

- Healthy adjacent teeth
- Intact facial bone
- No acute infection
- Ability to place the implant in the correct three-dimensional position for restoration
- Anticipated stability of the implant to allow immediate restoration

Multiple patient- and site-related factors need to be considered for this treatment in order to achieve predictable long-term functional and esthetic outcomes. If the criteria for the type 1A protocol are not met, alternative treatment options must be considered.

Patients undergoing implant therapy should have no medical or psychological contraindications to complex oral surgical and restorative procedures. Patients should have realistic expectations about the final outcomes, be fully informed, and have consented to undergo the type 1A protocol.

1. **What clinical experience is recommended for the type 1A protocol?**
   The type 1A protocol is classified as a complex procedure in the ITI SAC Classification (Dawson and coworkers 2021) and should be performed by clinicians experienced in surgical and restorative implant procedures. These clinicians should have skills specific to tooth extraction and immediate implant placement, hard and soft tissue augmentation procedures, and immediate loading/restoration of implants. A team approach is often needed.

The SAC Classification in Implant Dentistry 2nd Edition
Anthony Dawson, William Martin and Waldemar Daudt Polido
To view this material, you need to be an ITI Member.

2. **How should a patient be clinically assessed for the type 1A protocol?**
   A thorough clinical examination should be performed for the proper assessment of the patient and site. The patient should be assessed with the ERA (Esthetic Risk Assessment: ITI TG 10; SAC, 2nd edition) and Risk assessment for immediate implant placement in single-tooth sites (Chapter 5.2; Hamilton and coworkers 2023) to determine the patient and site-specific risk factors for immediate implant placement.
3. **What radiographs are recommended to properly assess a site for the type 1A protocol?**
   Radiographic assessment of the site and relevant surrounding tissues with a good quality periapical radiograph and a cone-beam computed tomography (CBCT) scan is strongly recommended. The following radiographic criteria should be fulfilled:
   - An intact or minimally damaged facial bone plate
   - Sufficient bone available to provide primary stability in an ideal 3D position
   - Health of the adjacent teeth
4. **Is software planning recommended for the type 1A protocol?**
   When a CBCT (digital volume) has been captured, the use of implant planning software is strongly recommended in order to evaluate the site and simulate the ideal 3-dimensional implant position. This allows the following to be analyzed:
   - The tooth-alveolus axis relationship to allow planning for optimal 3D restoration-driven implant placement
   - The gap between the implant and the facial bone wall at the level of the planned implant shoulder position
   - Abutment options
5. **What restorative preparation should there be prior to commencing treatment?**
   The prior fabrication and use of a traditional or computer guided surgical template is highly recommended to achieve an optimal restoratively driven three-dimensional implant position. A provisional crown, shell crown or matrix should be prepared prior to tooth extraction according to the desired method for fabrication of the planned immediate implant restoration. An alternative provisional prosthetic replacement of the tooth should be prepared and available in the event the treatment cannot be completed due to intraoperative events.
6. **How should the tooth be extracted when utilizing the type 1A protocol?**
   A minimally traumatic tooth extraction with a flapless approach is recommended and all efforts should be made to preserve bone and soft tissue integrity. Special instrumentation may be required to achieve this goal. Debridement of the socket should be performed. The integrity of the socket walls should be confirmed following extraction.
7. **What should be done if the facial bone is compromised when the tooth is extracted?**
   If the facial bone is compromised during and following tooth extraction, the extent of the defect must be assessed. If a minor defect in the facial bone is present, the type 1A protocol may still be considered. However, the risk of esthetic complications is increased and additional adjunctive hard and soft tissue regenerative procedures may be required. In larger defects, alternative treatment protocols to type 1A must be considered.
8. **Can the type 1A protocol be done in the presence of chronic periapical infection?**
   The type 1A protocol can be selected for teeth presenting with chronic periapical infections. However, it is recommended that this is only considered when the following conditions exist:
   - Absence of a fistula
   - Infection can be completely debrided
   - There is sufficient bone remaining to provide primary implant stability
9. **How big should the facial gap be?**
   The facial gap should ideally be > 2 mm in width at the level of the implant shoulder. However, this may not always be possible, and ultimately needs to be considered in relation to the likely functional loading, implant diameter, and the dimensions of the socket.
10. **What should be done when the facial bone or soft tissues are thin?**
    The following treatment can be considered:
    - In thin tissue phenotype situations, or when facial bone is thin (less than 1 mm), the type 1A protocol can still be considered. However, in addition to grafting

of the gap, adjunctive soft tissue grafting may be required to compensate for anticipated post-extraction dimension changes. This will increase the complexity of the procedure and risk of adverse outcomes.
- Alternative implant placement and loading protocols may also be considered to reduce the risk.

11. **What steps should be done for connection of the provisional crown to the implant?**
Immediate placement of a provisional restoration is well documented. This can be performed according to previous published consensus statements. The following factors should be considered:
- Screw retention is recommended.
- Emergence profile should be appropriate (not over- or undercontoured).
- Time frame should be from implant placement to 1 week after placement.
- Highly polished surface of the provisional is required.
- The occlusion scheme should be without any eccentric contacts.
- Light proximal contacts should be present.
- The provisional restoration should be inserted and the retaining screw (abutment or prosthetic) torqued according to guidelines published by each manufacturer.

12. **What should be done if the type 1A protocol cannot be completed at the time of surgery?**
If the type 1A protocol cannot be completed, the implant can be placed with simultaneous grafting and allowed to heal without loading the implant. If the implant cannot be placed, an early placement protocol can be considered. Alternatively, the socket may be grafted and followed by late implant placement.

2.6 Evidence for Type 1A Protocols: Immediate Implant Placement + Immediate Loading

For the type 1A protocol, Hamilton and coworkers (2023) identified 43 prospective (including data from 11 randomized controlled trials and 6 controlled clinical trials) and 25 retrospective cohort studies that fulfilled the inclusion criteria. These studies comprised 2,531 implants that were observed for a mean follow-up period of 2.6 years (SD: 2.3 years; range: 1–18 years). The weighted mean survival rate was 97,7% (95%-CI: 96.6%–98.4%).

In 23 studies, there was sufficient documentation to undertake an intention-to-treat (ITT) analysis. ITT is a statistical concept that calculates the proportion of the study population who complete the study without any major protocol violations (Gupta 2011). In the context of the type 1A protocol, not every implant intended for immediate placement and loading could be treated according to the protocol. The ITT analyses indicated a range of 85–100% of sites successfully treated according to the stated protocol. The main reasons for not proceeding with this protocol included: insufficient intact facial bone walls following extraction and lack of sufficient insertion torque following implant placement (Gallucci and coworkers 2018; Hamilton and coworkers 2023).

The clinical implications are significant. For a type 1A protocol, careful case selection is required, and clinicians should be aware (and patients advised) that there is a chance that the condition of the socket following extraction will not lend itself to immediate implant placement or that the criteria for the delivery of a provisional restoration immediately after implant placement may not be met. Therefore, contingency plans need to be made to amend the treatment plan, should it be impossible to proceed with immediate placement or immediate restoration/loading (Morton and coworkers 2018; Morton and coworkers 2023).

The majority of studies on the type 1A protocol have been limited to the maxillary incisors, canines, and premolars (Zhou and coworkers 2021). Very few studies reported a type 1A protocol for molar teeth, which is due to the limited patient-centered benefit and increased loading risks in this area. Only 2 studies were reported on the anterior mandible, with a low number of implants. This is likely related to the anatomical constraints in this region and limited mesiodistal space for single-tooth replacements.

High survival rates for immediate implants have been widely documented. However, risk factors for implant failure and esthetic complications have also been identified. In a systematic review comparing different implant placement and loading protocols, the reported mean implant survival rate for the type 1A protocol in partially edentulous patients assessed in 24 studies with a combined total of 1067 implants was 98.4% (range: 87.5–100%) with a median of 100% and a mean follow-up period of 28.9 months (Gallucci and coworkers 2018). For the type 1C protocol, 16 studies were evaluated with a total of 963 implants and a mean survival rate of 96% (range: 91.3–100%) after a mean follow-up period of 38.4 months (Gallucci and coworkers 2018).

The loading protocol was a driving factor for the increased variation in outcomes observed with the type 1A compared to the type 1C protocol. The potentially increased risk associated with immediate loading is specific to patients, locations, and sites and should be weighed together with the patient-centered benefits. When analyzed by location, the type 1A protocol has mostly been investigated in the maxillary anterior region. Immediate loading of immediately placed implants in the posterior molar regions has not been sufficiently documented to be recommended as a routine procedure. Where immediate implant placement is desired in posterior sites, the type 1C protocol with a customized healing abutment should be considered.

The esthetic outcomes of immediately placed implants have also been reported to be favorable (Chen and Buser 2014: Wittneben and coworkers 2023). However, an increased variability of esthetic outcomes was found compared to type 2 and type 3 placement protocols. It was suggested that variations in adjunctive procedures performed simultaneously with implant placement, as well as variation in the site-specific inclusion criteria, contributed to the variation in esthetic outcomes.

Midfacial recession of > 1 mm was the most frequently reported esthetic complication with immediate implant placement. Site-specific risk factors for midfacial recession following immediate implant placement have been reported, including defects of the facial bone plate, thin facial bone, and thin soft tissue phenotype.

Treatment variables contributing to esthetic risk have also been identified, including malposition of the implant, Implant size, grafting the buccal gap, a flapless surgical approach, connection of an immediate provisional, and connective tissue grafting. When the type 1A protocol is being utilized, the variability of esthetic outcomes was found to be reduced when combined with a flapless procedure, grafted buccal gaps, and connective tissue grafting.

2.7 Evidence for Type 1B Protocols: Immediate Implant Placement + Early Loading

Gallucci and coworkers (2018) identified relatively few studies on immediate placement and early loading in partially edentulous patients. Only one controlled clinical trial and two non-comparative studies were identified, comprising 43 implants. The weighted mean survival rate was 98.2% (median: 100%; range: 93.75–100%) with a mean follow-up period of 28 months (SD: 27.7 months; range: 12–60 months). There was insufficient data for an ITT analysis.

Due to the paucity of evidence, the authors concluded that while the type 1B protocol is clinically documented, it lacks sufficient evidence to be clinically and scientifically validated. Clinicians should therefore be cautious in recommending this protocol for implant placement and loading (Morton and coworkers 2018). When the literature is restricted to single-tooth replacements by intraoral location, no studies reported on the outcomes of type 1B protocols (Zhou and coworkers 2021).

2.8 Evidence for Type 1C Protocols: Immediate Implant Placement + Conventional Loading

A total of 6 comparative studies (5 randomized controlled trials, 1 controlled clinical trial) and 10 non-comparative studies were identified in the systematic review of Gallucci and coworkers (2018). Of 963 implants placed with a type 1C protocol, 24 implants failed, yielding a weighted survival rate of 96% (median: 99.2%; range: 91.3–100%). The mean follow-up period was 38.7 months (SD: 34.3 months; range: 12–120 months). The authors concluded that this protocol was scientifically and clinically validated and could be recommended, provided that strict inclusion and exclusion criteria were adopted (Morton and coworkers 2018).

In all, 5 studies provided sufficient data for an ITT analysis. Between 84.2% and 100% of sites could be treated as intended, according to the study protocols (median: 85.2%). Reasons for not proceeding with the intended treatment included sites with alveolar bone defects and loss of the facial bone wall encountered following tooth extraction, inadequate bone volume apical to the socket for primary stability, and gaps of < 1 mm between the implant and the facial bone wall.

Although clinically and scientifically validated, clinicians should be aware that between 15% and 20% of implants may be impossible to place according to the type 1C protocol. Strict inclusion and exclusion criteria should be observed to achieve predictable outcomes. If a type 1C protocol cannot be carried out, the clinician can abort the procedure or graft the socket with a suitable bone substitute for ridge preservation (Darby and coworkers 2009).

When identifying local site-related risk factors, type 1C protocols were scientifically and clinically validated in the anterior and posterior maxilla, clinically documented in the posterior mandible, and clinically insufficiently documented for anterior mandible (Zhou and coworkers 2021). This protocol is largely indicated for posterior tooth replacements where immediate loading presents greater risks with fewer benefits, provided the local site-specific factors are favorable for immediate implant placement.

3 Preoperative Analysis and Treatment Planning

F. Lambert, A. Hamilton, A. De Souza, W. Martin

Preoperative patient- and site-specific analysis is one of the key aspects of predictable success with immediate implant treatment. As discussed in Chapter 2, our understanding of the principles of wound healing and of changes in the surrounding alveolar bone following tooth extraction has shaped our current thinking regarding implant placement protocols. They are partly determined by the genetic sequence of events in the wound-healing cascade, but also largely influenced by the surrounding hard and soft tissues.

The anatomy of the socket also influences the predictability of obtaining primary stability and the intraoperative conditions required for predictable immediate loading of a dental implant in a fresh extraction socket (immediately placed dental implant). This chapter reviews the current concepts in patient and site assessment/selection designed to minimize risk and provide predictable outcomes with immediate tooth replacement.

3.1 Patient Characteristics

3.1.1 Medical Status

The overall health of a patient should always be carefully assessed when selecting a dental implant procedure, given the inherent surgical risks. Regarding immediate placement and loading, patients with certain systemic conditions may have increased risks of an adverse event, implant failure, postoperative complications, and delayed or compromised wound healing (Bornstein and coworkers 2009).

Where local anatomical parameters permit flapless immediate placement, it can be associated with low surgical morbidity and with a reduced risk of postoperative bleeding, swelling, and pain. This can eventually be beneficial for patients who present with systemic conditions or who are taking medications that increase the surgical risk of bleeding, or who are otherwise poor candidates for invasive surgery.

However, systemic conditions that compromise wound healing and osseointegration may represent an additional risk in immediate placement or immediate loading. In osteoporosis patients taking antiresorptive medications, slower bone remodeling and soft tissue healing may delay the process of osseointegration; more conventional delayed implant placement and loading procedures may therefore be preferred.

The same applies to heavy smokers, or patients with certain immunodeficiency conditions, or poorly controlled diabetes, where healing delays may compromise the success of an immediate procedure. In patients with compromised healing, the risk-to-benefit balance should be assessed when establishing the treatment strategy, and a staged approach is recommended.

3.2 Esthetic Analyses and Esthetic Challenges

An Esthetic Risk Assessment (ERA) for the treatment of partially edentulous patients with dental implants was first introduced in Volume 1 of the ITI Treatment Guide (2004). It was developed to assist clinicians in the diagnosis and planning of partially edentulous patients for treatment in the esthetic zone, and to identify clinical factors or situations that could contribute to esthetic compromise. Understanding that implant therapy in the esthetic zone can be a challenging process, as patient demands on esthetics coupled with preexisting deficiencies in the anatomy could present obstacles to obtain ideal results, the ERA table has become a valuable tool to identify risk prior to initiating care.

In 2017, the ERA table was updated to reflect current practice trends and technology as discussed in detail by Martin and coworkers (2017) in Volume 10 of the ITI Treatment Guide. The ERA table can also be found in the second edition of the SAC Classification in Implant Dentistry (Dawson and coworkers 2021) (Table 1).

The ERA table identifies 13 clinical factors that can add risk to the ability to achieve ideal esthetic outcomes. In a specific clinical situation, there may be many more of these factors.

With the introduction of immediacy in the esthetic zone, several pre- and intraoperative factors require attention to minimize esthetic compromise and enhance overall success. Clinicians performing this type of rehabilitation must have a thorough understanding of hard and soft tissue biology and all available treatment modalities for a given clinical situation. For the purposes of this volume, the ERA table will be considered as a factor in the overall treatment of patients with dental implants.

When planning an immediate implant and restoration in the esthetic zone, it is also recommended to perform a conventional or digital smile analysis to set the final objective, to evaluate the clinical challenge, and to establish the optimal treatment strategy (Fig 1).

ITI Treatment Guide Vol. 1
Implant Therapy in the Esthetic Zone – Single-Tooth Replacements
Urs Belser and coworkers
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ITI Treatment Guide Vol. 10
Implant Therapy in the Esthetic Zone – Current Treatment Modalities and Materials for Single-Tooth Replacements
Vivianne Chappuis and William Martin
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The SAC Classification in Implant Dentistry 2nd Edition
Anthony Dawson, William Martin and Waldemar Daudt Polido
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Fig 1 Clinical scenario: An ankylosed tooth 11 needs to be replaced. The gingival margin position may be considered as unfavorable when compared to the neighboring tooth margins. and a type II or III implant placement may be preferred. However, based on the digital esthetic analyses (line overlay), the cervical level of tooth 11 is correct; the neighboring tooth margins should be lengthened for a more harmonious smile. Eventually, immediate placement may be considered. (Esthetic analyses/Image courtesy of Prof Amélie Mainjot.)

Table 1 Esthetic Risk Assessment (ERA) table outlining the factors that can be assessed to determine the level of esthetic risk associated with implant tooth replacements irrespective of the protocol for implant placement or loading. (From Chappuis and Martin 2017; Dawson and coworkers 2021.)

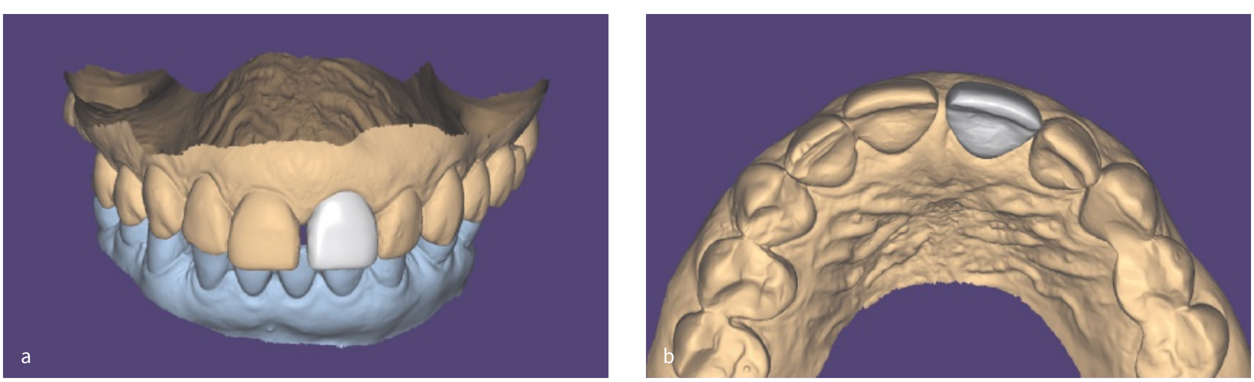
Esthetic risk factor	Level of risk		
	Low	Medium	High
Medical status	Healthy, uneventful healing		Compromised healing
Smoking habit	Non-smoker	Light smoker (≤ 10 cigs/day)	Heavy smoker (> 10 cigs/day)
Gingival display at full smile	Low	Medium	High
Width of edentulous span	1 tooth (≥ 7 mm)[1] 1 tooth (≥ 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 of alveolar crest	No bone deficiency	Horizontal bone deficiency	Vertical bone deficiency
Patient's esthetic expectations	Realistic expectations		Unrealistic expectations

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

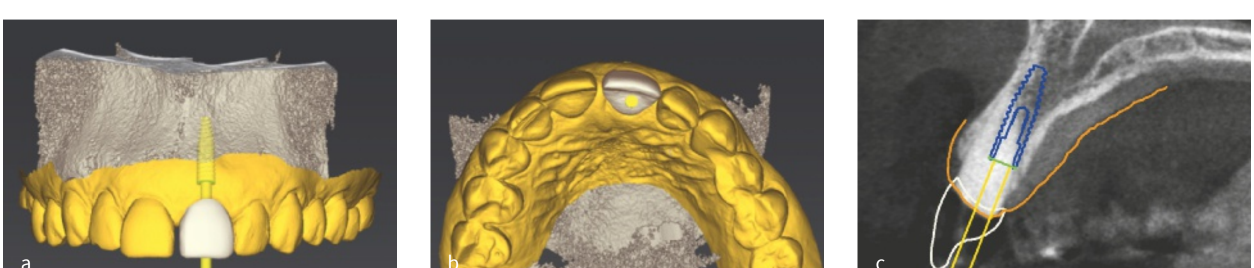
3.3 Prosthodontic Planning

Contemporary implant planning recognizes the important relationship between the prosthodontic and biological outcomes to achieve long-term functional and esthetic success. The term “restoration-driven implant planning” is often used to highlight that this relationship begins with an understanding of the desired prosthodontic reconstruction. The design of the restorations is determined through a digital diagnostic tooth set-up, or alternatively, a conventional diagnostic wax-up, which can be scanned and digitized for implant planning (Figs 2a-b). This predetermined prosthodontic design is then used to assist in determining the most biomechanically suitable implant specification and position.

To visualize this relationship, it is recommended for the prosthodontic design to be registered and incorporated into a virtual implant-planning environment where it can be assessed in relation to the anatomical data acquired from a cone-beam computerized tomography (CBCT) scan (Figs 3a-c). During the virtual implant planning process, if anatomical challenges and limitations are present clinical decisions can be made regarding regenerative approaches with bone and soft tissue augmentation, or possible modification to the prosthetic planning.



Figs 2a-b Digital diagnostic set-up for a fractured tooth 21.



Figs 3a-c Comprehensive virtual implant planning for an immediate replacement of tooth 21. Registration of CBCT DICOM data with intraoral surface scans and a digital diagnostic set-up.

3.3.1 Diagnostic Wax-Up/Digital Diagnostic Set-Up

Determining the prosthodontic design is the first step in the planning process. In situations where immediate placement and restoration are planned, the existing tooth may supply this information, provided its clinical crown meets all of the objectives of the final restoration. If not, it is recommended to perform a diagnostic wax-up or digital diagnostic set-up to precisely determine and analyze the key determinants of implant planning:

- Incisal edge position
- Prosthetic volume
- Proposed mucosal margin position
- Interarch prosthetic space
- Deficiencies of the alveolar ridge and soft tissue

The diagnostic process should yield the external shape of the immediate provisional restoration. It may include a putty index of the diagnostic wax-up or a 3D-printed digital diagnostic set-up. Alternatively, the diagnostic tooth can be used in the design and fabrication of a shell temporary for direct pick-up, or it may be copied digitally for indirect fabrication of the provisional from an impression or intraoral scan made at the surgical appointment.

3.3.2 Occlusal Assessment

As part of the prosthodontic evaluation, it is imperative for the occlusion to be carefully assessed to determine the anticipated biomechanical loads on the planned rehabilitation. This will be equally important for planning the definitive restoration and for assessing the suitability of the site for immediate loading.

Although firm scientific evidence is lacking regarding the optimum occlusion for implant restorations, for single-tooth restorations it is generally accepted that an implant protected occlusion is ideal (Rilo and coworkers 2008; Koyano and Esaki 2015). This entails an absence of occlusal contacts in maximum intercuspation at light biting forces and only light contact at heavy biting forces, as well as the absence of excursive contacts, which should be distributed across the remaining natural dentition. This recommendation needs to be seen in the context of the patient's overall dentition, occlusal scheme, tooth being replaced, status of the adjacent teeth, and esthetic requirements. As such, the elimination of excursive occlusal contacts on the proposed restoration is not always desirable or even possible. However, this aspect should be taken into consideration when selecting an appropriate implant design, material, and diameter, as well as the prosthetic design and restorative materials.

All implants restored within the first week after implant placement are considered to be immediately loaded. The term "immediate loading" should still be applied for immediate provisional restorations that are completely free of occlusal contact, as it is recognized that during mastication and movements of the oral tissues, the restoration will still be loaded. However, we should distinguish whether the restoration is immediately loaded with occlusal contact, or immediately loaded without direct occlusal contact.

The majority of clinical studies on immediate loading of immediately placed implants in partially edentulous patients have reported no occlusal contacts on the provisional implant restoration in either maximum intercuspation or excursive movements (Zhou and coworkers 2021). This is to limit micromovement of the implant that may be caused by occlusal contacts, particularly in the presence of parafunction, leading to failed osseointegration. Literature on immediately loaded single implants with full occlusal contact is limited (Zhou and coworkers 2021).

Non-axial loading of immediately placed implants is likely to have the most detrimental effects and is more likely to be encountered in anterior teeth due to the angle of the alveolus relative to the clinical crowns, as well as the angle of occlusion formed by the vertical and horizontal overlap. Teeth that are the sole determinants of anterior guidance during excursive mandibular movements are the most subject to non-axial loading. When these teeth are planned for replacement, immediate loading would be contraindicated unless the guidance can be temporarily transferred to another tooth by flattening and shortening the cusps or incisal edge of the immediate provisional restoration, which may result in esthetic compromises (Fig 4). The full range of mandibular movements should be carefully assessed for contacts in excursion, including all paths into and returning from mandibular crossover positions.

Fig 4 Shortening of an immediate provisional restoration on an immediately placed implant 11 to relieve any protrusive contacts.

The presence of occlusal parafunction, as determined by signs of attrition or a history of tooth fractures, also present as a risk factor for implant failure with immediate loading. Fremitus and mobility of adjacent teeth should also be considered risk factors in the occlusal assessment and may preclude an implant-protected occlusal scheme.

3.3.3 Alternative Provisional Restorations (Plan B)

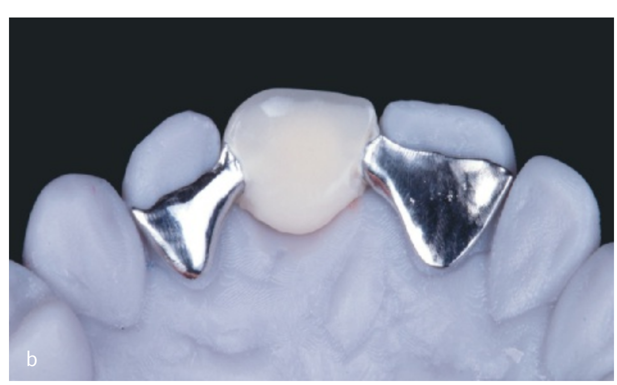
As a part of planning for the immediate implant and loading protocol (type 1A), it should be recognized that if preoperative risk factors are identified or intraoperative criteria are not met, immediate loading of immediately placed implants may not be possible or recommended. It is advisable to discuss this with the patient before initiating treatment and to keep a pathway for an alternative interim tooth replacement readily available.

The alternative solutions for interim tooth replacement during early or conventional implant loading protocols are highlighted in more detail in Chapter 10 of Volume 10 of the ITI Treatment Guide (Martin and coworkers 2017). They may involve one of the following:

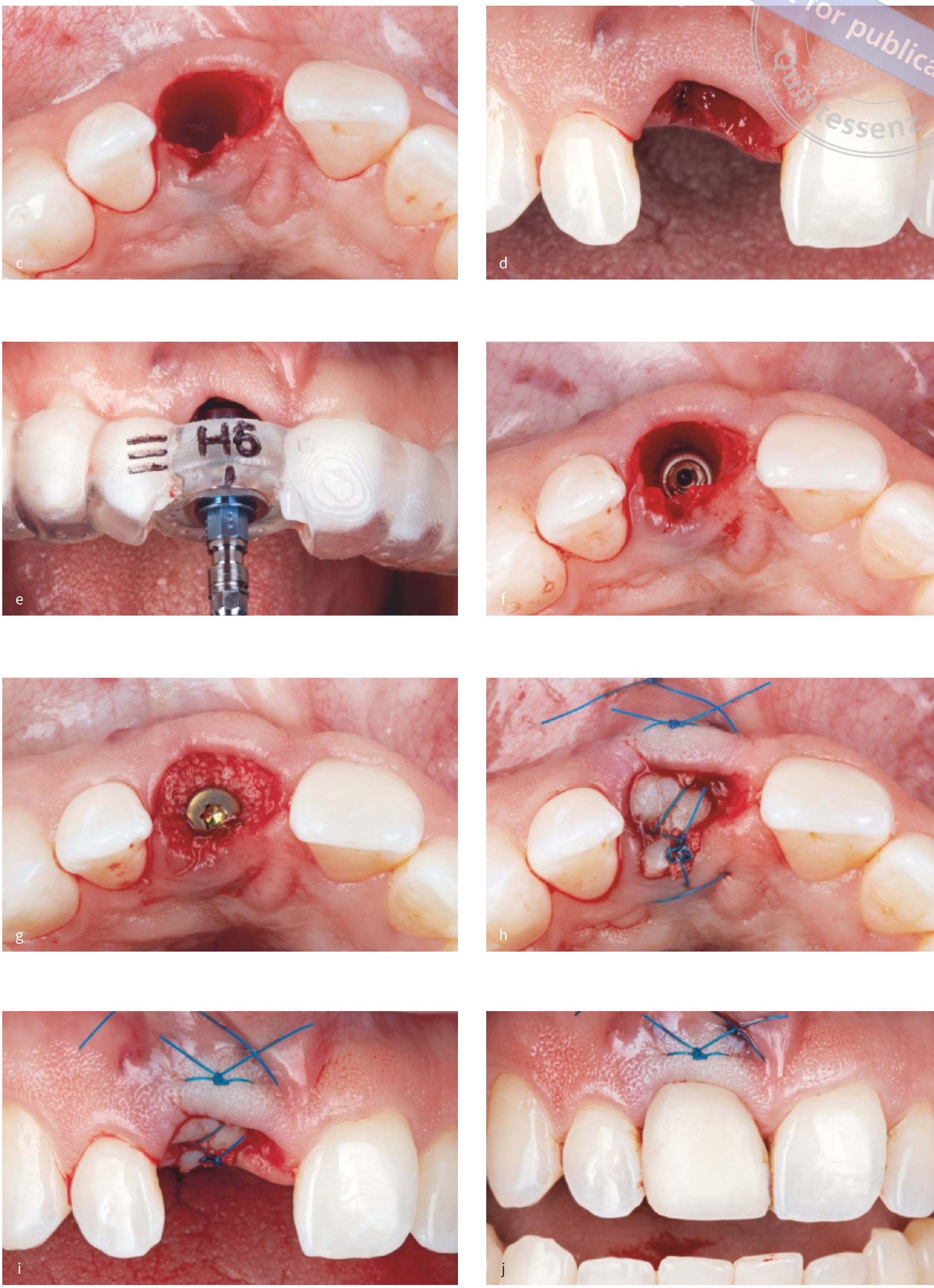
- Indirect resin-bonded provisional fixed bridge
- Direct resin-bonded provisional fixed bridge
- Conventional fixed provisional bridge (where adjacent teeth are planned for restoration with crowns)
- Removable suspension bridge (ESSIX-style retainer)
- Removable partial denture
- Orthodontic retention

Although the literature on type 1A protocols demonstrates comparable survival rates, this does not exclude additional risks when immediately loading an immediately placed implant. Where suitable alternative fixed provisional restorations are readily available during the healing phase, such as when adjacent teeth are already planned for crowns and a provisional fixed bridge can be provided, type 1C protocols may be more justifiable. In this case, prosthetically guided soft tissue healing, socket management, and grafting should be delivered using an appropriately designed and shaped pontic. This pontic should support the mucosal tissues and contain any graft biomaterials in the socket in the same manner as an immediately loaded provisional restoration (Figs 5a-j).

a



b



Figs 5a-j Resin-bonded bridge pontic used to provide prosthetically guided soft tissue healing over an extraction socket and immediately placed implant.

3.4 Surgical Planning

Surgical planning according to the predetermined prosthodontic design of the implant restoration is based on esthetic and functional analyses, an assessment of local bone anatomy and volume using 3D imaging (CBCT), and a clinical evaluation of the soft tissue conditions. As part of the planning process, the suitability for immediate placement and immediate loading will be determined, together with specific procedural details including the length, diameter, design, and position of the implant and the need for adjunctive surgical procedures.

3.4.1 Bone Conditions

Planning for immediate placement involves careful evaluation of the site-specific bony anatomy. A comprehensive preoperative 3D radiographic examination (e.g., by CBCT) should be performed to evaluate whether the alveolar bone is adequate to satisfy the criteria for immediate placement. Although 2D plain-film radiographs are commonly used in implant dentistry, when considering flapless immediate placement, it is highly recommended to consider 3D imaging as a routine primary imaging modality (Bornstein and coworkers 2017).

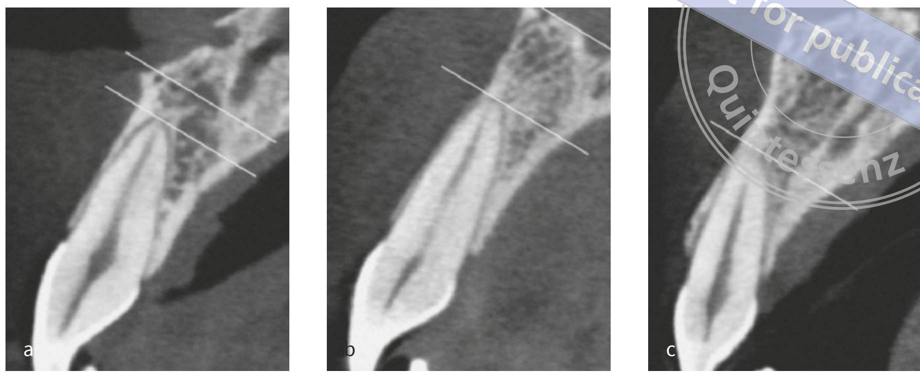
Bone anatomy and type of socket. To obtain primary stability in immediate placement, both in the anterior and in the posterior regions, several anatomical considerations should be preoperatively evaluated. Important site-specific landmarks such as the nasal floor, maxillary sinus floor, mandibular canal, accessory canals, lingual concavity, etc., should be identified when planning for immediate placement. Moreover, the socket anatomy and its relationship with the alveolar and basal bone are also determinants in evaluating the possibility to immediately place and load an implant. These characteristics are different in the anterior and in the posterior regions.

Anterior region. In the anterior maxilla, the anatomy, shape, and availability of basal and palatal bone are the most crucial bone structures for the anchorage of an immediate implant. In a clinical study, Botelho and coworkers (2020) found that the basal bone has a trapezoidal shape with a larger dimension in the lateral incisor site and smaller dimensions in the canine sites. Along with larger root dimensions, this makes it more difficult to obtain primary stability in the canine area compared to central or lateral incisors. In these areas, the maxillary nasal floor will be the apical boundary and, together with root length, will determine the height of the basal bone (Figs 6a-c)

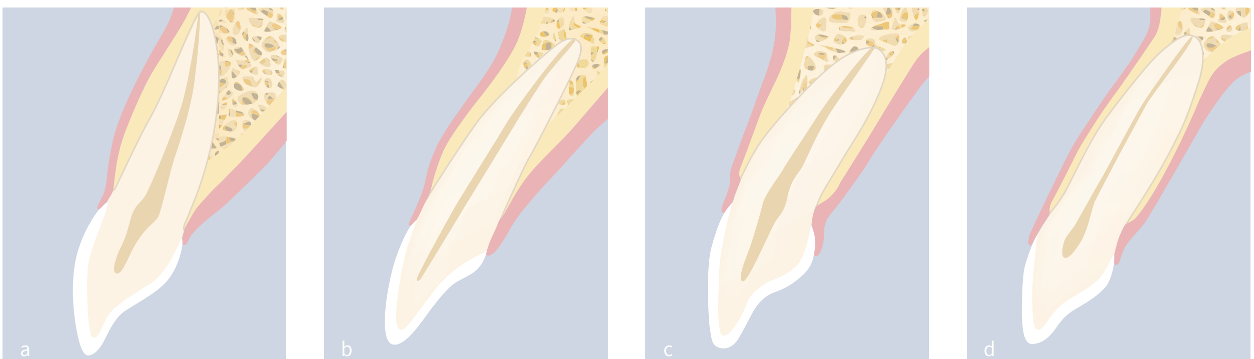
Other factors such as root shape, length, and position related to the alveolar process are also important. A CBCT study by Kan and coworkers (2011a) demonstrated the relationship between sagittal root position and the alveolar bone housing.

Root positions are classified as class I to class IV:

- Class I: Root positioned against the facial cortical bone
- Class II: Root positioned in the middle of the alveolar housing without engaging either the facial or the palatal cortical plates at the apical third of the root
- Class III: Root is positioned against the palatal cortical plate
- Class IV: At least two thirds of the root engages both the labial and the palatal cortical plates.



Figs 6a-c CBCTs of central incisors demonstrating variability in available apical bone for primary stability of immediately placed implants which is related to the root length and proximity of the nasal floor.



Figs 7a-d Classes of sagittal root positions related to the alveolar bone housing. Left: Class I sagittal root position. Middle left: Class II sagittal root position. Middle right: Class III sagittal root position. Right: Class IV sagittal root position.

Based on the results of this study, in the maxillary anterior region, class I was the most predominant root position, accounting for 86.5% in central incisors, 76% in lateral incisors, and 81% in canines (Figs 7a-d) (Kan and coworkers 2011a).

These findings demonstrate the significance of the palatal bone for primary stability in the anterior maxilla in most clinical scenarios. However, it also highlights the thin facial wall. Caution should be exercised in class IV root position, which is unsuitable for immediate placement due to the lack of labial or palatal bone (Fig 8).

Fig 8 A class IV root position. It is not a result of pathological bone loss but due to a genetic variation of the local anatomy and alveolar bone contours in the presence of healthy periodontal tissues.

Dental implants are used routinely throughout the world to replace missing teeth. With the broadening of treatment options and an increasing number of clinicians that provide implant therapy, it is important to ensure that the treatment methods used meet the highest clinical standards.

The ITI Treatment Guide series is a compendium of evidence-based implant-therapy techniques in daily practice. Written by renowned clinicians and supported by contributors from expert practitioners, the ITI Treatment Guides provide a comprehensive overview of the various indicated treatment options. The management of different clinical situations is discussed with an emphasis on sound diagnostics, evidence-based treatment concepts, and predictable treatment outcomes with minimal risk to the patient.

Volume 14 of the ITI Treatment Guide series aims to provide a comprehensive overview on immediate implant placement and immediate loading protocols for replacement of single or multiple teeth requiring extraction. This volume outlines the current literature on immediate implant placement and immediate loading and elaborates on our understanding of the biology surrounding tooth extraction and osseointegration that underpin these treatment concepts.

The importance of patient and site selection in conjunction with comprehensive treatment planning is highlighted and a risk assessment tool to aid decision making is provided. All key aspects of both the surgical and loading procedures are described in order to provide protocols that optimize the final treatment outcome.

This volume also presents 9 step-by-step clinical cases performed by experts in the field, and typical complications of immediate implants are discussed, along with recommendations on how these can be prevented.

ITI Treatment Guide – Step by Step to Success

- For Sound Diagnostics
- For Evidence-Based Treatment Concepts
- For Predictable Outcomes

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