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The Tissue-Level Implant

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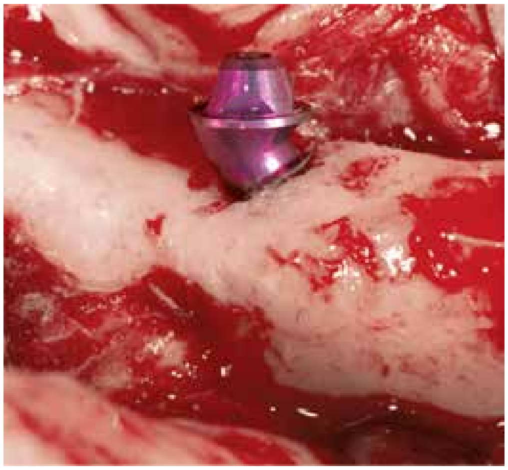


FIG 5-1 A 30-degree screw-retained abutment (SRA) corrects the tilted axis of the BL implant.

The restoration of missing teeth with dental implants has become very predictable over the last 30 years. This revolutionary treatment concept for oral rehabilitation has been based on the concept of osseointegration or functional ankylosis, as described by Brånemark and Schroeder, respectively.[1–4] *Osseointegration* is defined as the intimate contact of titanium oxide on the surface of dental implants with the proteoglycans of the adjacent bone without any soft tissue interface.

The Gold Standard

The minimal morbidity associated with the surgical placement of dental implants, the short- and long-term successful outcomes, and the positive physical and psychologic impact on the patient's quality of life all have resulted in the notion that rehabilitation of missing teeth with dental implants is the gold standard.[5,6] Success with dental implants has occurred following the axial, two-stage, delayed loading protocols. To implement these protocols, a traditional bone-level (BL) or two-piece implant is the solution most commonly used by many practitioners to provide implant dentistry for their patients.

Following the original protocols for implant placement, the implant is submerged below the overlying soft tissues at the time of placement. The implant is placed with its platform flush with the edentulous crestal bone, the marginal bone. After 3 to 6 months of osseointegration, the implant is uncovered, and a temporary healing abutment replaces the cover screw and thereby extends the implant through the overlying soft tissues and into the oral cavity.

The practicality of the two-piece BL implant is due to the versatile restorative abutment portfolio available to support the fabrication of the intended prosthesis. The ability to restore two-piece implants using straight, preangulated, or custom angulated abutments allows for their use to replace any missing tooth or teeth.

In the contemporary implant practice, in order to minimize or eliminate posterior cantilevers in the fully edentulous maxillary or mandibular arches, the anteroposterior (AP) spread of the implants is increased by tilting the posterior implants. The tilted and therefore "off-axis" implants are restorable by using prefabricated angulated abutments that allow the prosthetic correction of all the implants within the arch form with the resultant fabrication of a screw-retained fixed prosthesis (Fig 5-1).

By having the implant platform at the marginal bone level, the connection of the abutment to the implant platform is therefore subgingival. The microgap, the junction of the base of the abutment with the top of the implant platform, has been a topic of debate among the implant practitioners.

The microgap is thought to potentially harbor bacteria, and this will result in marginal bone loss over time. In an attempt to eliminate or to minimize the potential harboring of bacteria at the microgap, the profile and design of this subgingival connection has been studied. A brief discussion of the different designs of the implant platform and the abutment base, including external versus internal connections as well as butt-joint vs platform-switching designs, follows later in this chapter.

In contrast to the two-piece implant, the one-piece implant lacks the subgingival microgap because the abutment and the implant threads are milled as a single unit. Once placed, the restorative platform is at the level of the free gingival margin. This implant design essentially has a straight abutment attached to the implant threads and therefore is limited in its versatility to restore cases where misalignments need to be corrected by using angulated or custom abutments.

The purpose of this chapter is to highlight the limitations as well as the advantages of the one-piece implant. By understanding the design features of both the two-piece as well as the one-piece implant, practitioners can make better clinical decisions for the use of either implant design.

Peri-Implant Soft Tissue Topography

Structures that penetrate the gingiva in the oral cavity, such as teeth and implants, travel through epithelium as well as connective tissue. The seal formed by the soft tissue cuff around teeth or implants is what separates the internal structures (ie, the marginal bone) from the external structures (ie, the oral cavity). The placement of a one-piece, nonsubmerged, tissue-level (TL) implant allows for the formation of this biologic width from the initial date of implant placement.[7,8] Therefore, sulcular depth, epithelial attachment, and connective tissue make contact with the implant surface. This implant–gingival tissue connection forms a similar barrier as the dentogingival tissues of natural teeth. Integration of all three tissue types—bone, connective tissues, and epithelium—all lead to the long-term stability of TL implants.

Just as titanium oxide and bony tissues have an intimate relationship once dental implants have healed, in 1981, Schroeder et al[9] described a similar relationship between the epithelial tissue and subcrestal connective tissue with titanium. They demonstrated that a stable attachment of the soft tissues to the extraosseous titanium can be maintained over time.

The growing interest in the favorable attachment of titanium to hard and soft tissues at edentulous sites led to clinical evaluation of nonsubmerged implants in the mid 1970s. The subsequent early research showed that the titanium-plasma-sprayed (TPS) implants used in the rehabilitation of the edentulous mandibular ridges with bar-supported overdenture prostheses were predictable and stable over time.[10–12] During the 1990s, several clinicians, including Drs Buser, Cochran, Listgarten, and others, reconfirmed and further expanded on the research of Schroeder with regard to the favorable attachment of soft tissues to titanium.[13–18]

Versteegh et al and ten Bruggenkate et al[19,20] expanded on the application of nonsubmerged implants, reporting favorable results using the one-piece, nonsubmerged implant in conventional single sites as well as partially edentulous arches. The favorable studies led to the formation of the International Team for Implantology (ITI) in 1980, which partnered with leading implant manufacturer Straumann to develop the ITI Dental Implant System in the mid 1980s. The nonsubmerged implant was used for treatment of patients with partially edentulous dentition, including single teeth as well as distal extension cases. Multiple papers supported the long-term survival of the nonsubmerged implant, and in 1997, Buser et al[21] published the 8-year life table analysis of a multicenter study using over 2,300 implants with a cumulative survival rate of 96.7% and a cumulative success rate of 93.3%. Also, prospective multicenter clinical studies looking at the ITI Dental Implant System have widely documented up to 10 years of prospective follow-up with success rates well above 90%.[9]

When comparing and contrasting two-piece versus one-piece implants, the discussions are about the maintenance of marginal and crestal bone levels over time. As summarized by Hermann et al,[22] multiple factors affect the level of the marginal bone, including the following:

- Occlusal trauma
- Biologic width establishment
- Gingival biotype
- Insertion torque of the implants
- Timing of prosthesis loading
- Thickness of the remaining bone
- Type of surgery
- Primary stability
- Lack of bone-to-implant contact (BIC)
- Bacterial colonization of the implant-abutment junction
- Macro and micro characteristics of the abutment and the coronal portion of the fixture
- Position of the implant

The implant-abutment junction, the microgap as it relates to the crestal bone levels, is also a contributing factor to the long-term maintenance of the marginal bone. Historically, the microgap that exists between the implant platform and the base of the abutment is at the crest of the alveolar bone, which may lead to crestal bone loss of up to 2 mm in the first year after implant placement.[23] Oh et al[24] and Tatarakis et al[25] in their publications also suggest that peri-implant infections and bacteria are the main cause of marginal bone loss.

In 2017, Sasada and Cochran[26] outlined the potential causes of bone loss with conventional two-piece implants as the following:

- “Natural” remodeling after implant placement
- Surgical trauma
- Loss of crestal blood supply
- Establishment of biologic width
- Reaction to stress
- Occlusal loading
- Influence of disconnection and reconnection of the abutment
- Response to bacteria from contaminated implant components

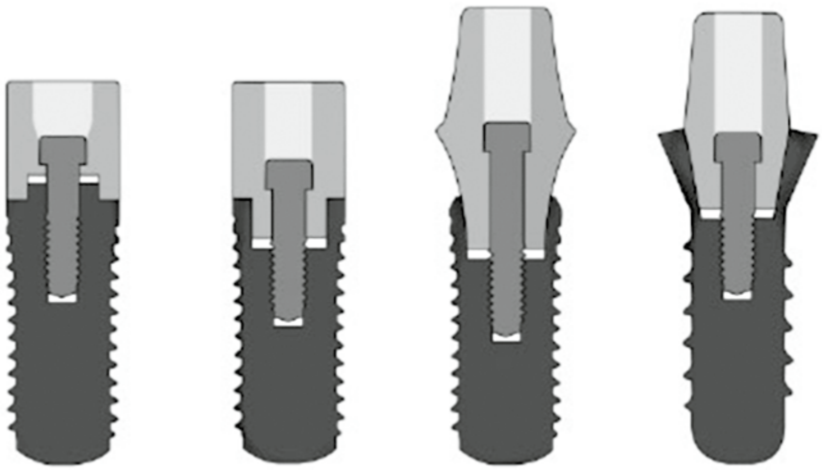


FIG 5-2 Butt-joint versus platform-switching connections.

Barone et al[27] also reminded clinicians that several other factors influence the preservation of hard and soft tissues around dental implants, including the following:

- The clinician's experience
- Loading time
- Surgical protocol
- Implant neck configuration
- Implant-abutment connection
- Insertion torque
- Oral hygiene/maintenance
- Simplified prosthetic procedure, presenting an ideal basis for cemented implant restorations

As mentioned earlier, a potential cause of marginal bone loss may be in part due to the different implant-abutment connection profiles, including external butt joint, internal butt joint, platform switched, and tissue level (Fig 5-2).

The butt-joint connection

With the presence of a microgap with a butt-joint profile, Hermann et al[23] and Adell et al[28] reported that marginal bone loss was predicted. The marginal bone loss was observed immediately after the abutment connection prior to placing the implants in function; the authors stress that this finding reduces the role occlusion plays as the etiology of early as well as marginal bone loss over time.

Observing this early marginal bone loss, Albrektsson et al[29] suggested that the success criteria for implants restored with a butt-joint connection included 1.5 mm of bone loss in the first year and less than 0.2 mm bone loss annually thereafter. The reason for including the first year specifically in their statement was that the first radiograph taken after the implant placement was at the time of the abutment connection, which was approximately 1 year after the initial surgical procedure.

Platform switching

The platform-switching connection attempts to reduce the marginal bone loss by shifting the implant-abutment interface horizontally. The origin of platform-switching abutments was the unavailability of matching wide abutments for restoring implants of wider diameter. Therefore, abutments of a smaller diameter than that of the implant were used in the restorative phase; hence, the evolution of platform-switching abutments. With platform-switching abutments, Cochran and colleagues[30] observed a lesser degree of bone loss than with implant restorations with butt-joint connections.

The most impressive finding of their study was that the connective tissue covered the microgap at the implant-abutment interface for implants restored with platform-switching abutments, whereas in implants restored with the butt-joint restorations, the apical extension of the junctional epithelium was always below the microgap. The authors concluded that the reduction in the biologic remodeling of bone as seen with the platform-switching abutments was due to the reduction in the bacterial load at the implant-abutment interface as well as increased stability due to the Morse taper–like connection of the platform-switching abutment to the implants with an internal connection.

Hermann et al and King et al in their 2001 and 2002 studies[31,32] demonstrated that the internal cone connection is more stable than the external hex connection. Many authors[33,34] have reported on inflammation as being the cause of bone resorption or bone loss. Therefore, the elimination of the microgap at the implant-abutment connection would be ideal to prevent inflammation at the marginal bone level.

The stability of the implant-abutment junction (ie, the microgap) influences the stability of the marginal bone levels as the inflammation-induced bone resorption is reduced. The adoption of the "one-stage" protocol where the temporary healing abutment is placed at the time of implant insertion was the first attempt in trying to stabilize the soft tissues at the microgap. This modification was initially reported by Becker et al and Bernard et al showing favorable osseointegration as compared to the traditional two-stage approach.[35,36] However, the microgap still remained at the crestal bone, whereas the TL implant places the microgap 2 to 3 mm above the crestal bone[37] (Fig 5-3).

The one-piece, nonsubmerged implant eliminates the microgap at the implant-abutment junction. It is usually made with two different surface topographies. The implant threads have an enhanced surface to promote contact osteogenesis, whereas the extraosseous/soft tissue portion is machined titanium.

The one-piece nonsubmerged implant offers several clinical advantages:

- A second surgical procedure can be avoided.
- The lack of a microgap at the bone crest can lead to stable crestal bone levels.
- The implant shoulder is at the soft tissue level.

With the benefits of one-piece implants in mind, in the contemporary literature, studies have been carried out to show whether submerging implants during the osseointegration phase would have an adverse effect on the rate of osseointegration.[8,38–40] The results comparing the hard and soft tissue integration of titanium implants, whether using one-piece or two-piece implants, were consistent with no significant differences observed. Therefore, clinicians should feel comfortable performing one-stage implant surgery placing either a BL implant with its temporary titanium abutment or using a one-piece implant.

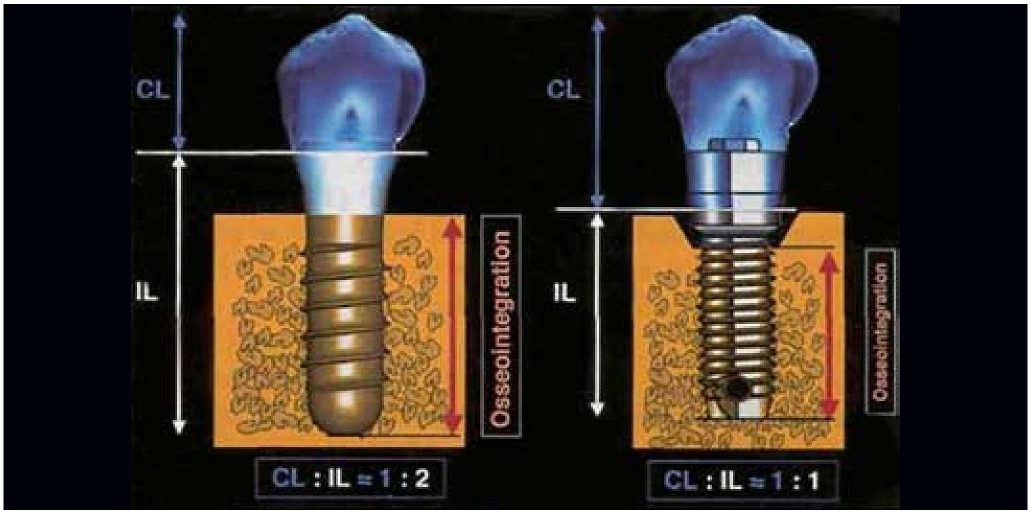


FIG 5-3 Crestal bone loss associated with the microgap close to the alveolar crest. CL, crown length; IL, implant length.

In 2000, Cochran[41] discussed the report from a consensus conference on Straumann dental implants including the ITI Dental Implant System, documenting that with one-piece, nonsubmerged implants, clinical studies showed epithelial structure attachments to the extraosseous portion of the implant similar to teeth. This systematic review demonstrates that a connective tissue zone exists between the apical extension of the junctional epithelium and the alveolar bone. This dense circular avascular zone of connective tissue fibers surrounded by a loose vascular connective tissue is very similar to what is found around teeth.

In 2018, Kim et al[42] conducted a retrospective radiographic study of 1,692 Straumann TL implants placed over the last 10 years. The group's conclusion was consistent with a 10-year cumulative survival rate of 98.23%. They reported a low failure rate with the TL implant, but the reasons for their failures were associated with implant length, diameter, insertion torque, and site—not the one-piece design. Most implants failed within the first year, and the authors cautioned the placement of implants with an insertion torque of less than 20 Ncm, which is consistent with the conventional surgical mindset.

One-Piece Implant: The TLX

Early and immediate implant procedures are outperforming the number of late implant placement procedures.[43] More predictable outcomes are also seen in patient populations with compromised presenting conditions and reduced bone quality or limited bone quantity.[44,45] These trends require constant attention to the design principles of dental implants and surgical workflows to meet the biomechanical and biologic requirements.[46–48] Primary implant stability is clearly one of the key criteria in this context.[49] Optimal initial or primary implant stability (ie, at time of implant placement) is considered as a prerequisite for the establishment of osseointegration and is therefore considered as indicative for the prognosis of implant success.[50,51] Its direct routine assessment as part of clinical procedures by means of resonance frequency analysis or insertion torque measurements is well established.[47] Tapered implants have evolved as prominent candidates to improve and facilitate achieving primary stability.[52]

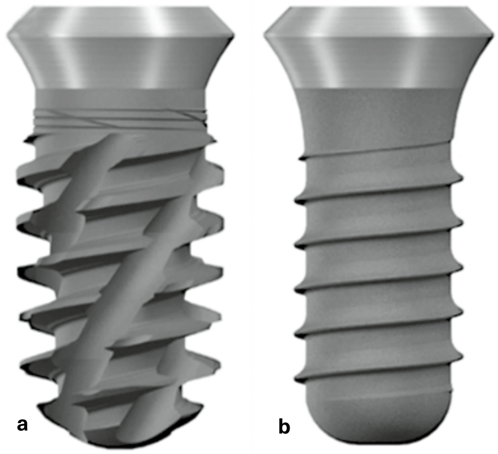


FIG 5-4 TLX implant *(a)* compared with TL implant *(b)*.

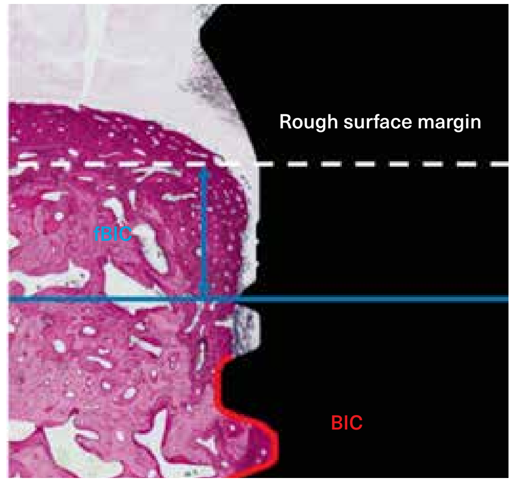


FIG 5-5 BIC is seen along the enhanced surface of the TLX implant.

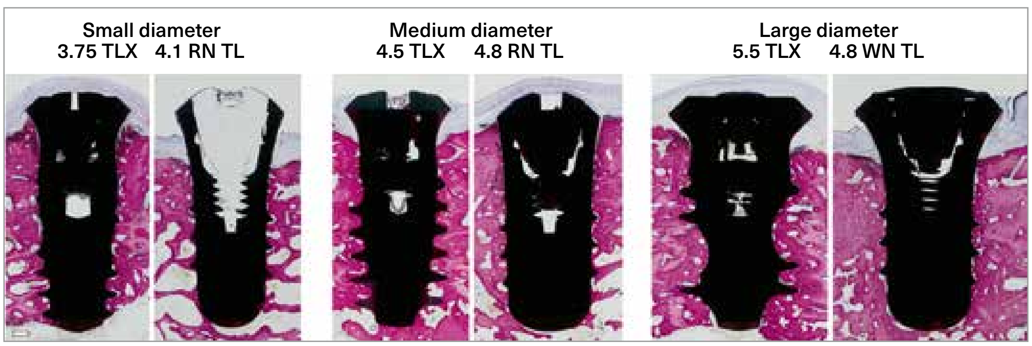


FIG 5-6 BIC is consistent and stable between the different diameters of the TLX and the TL implants.

With the marginal bone level as well as the soft tissue benefits of the nonsubmerged, one-piece implant, the new generation of this type of implant is referred to as the TLX (Straumann). The TLX implant also has two different surface topographies. The intraosseous portion is enhanced with acid-etched technology, whereas the extraosseous soft tissue portion is machined titanium.

The TLX implant is very similar to its predecessor the TL implant (Fig 5-4). The implant threads are the same as the BLX implant (Straumann), which allow for better initial stability due to the fully tapered design with progressive widening as well as thickening of the threads from the apical portion upward to the last most coronal thread. The "neck" or platform of the implant is slightly narrower than the widest, most coronal thread, thereby reducing the lateral compression on the avascular crestal cortical bone as the implant base attaches to the platform-switching profile of the soft tissue portion of the implant.

El Chaar and colleagues, in a 2021 study, compared the one-piece TLX implant to the existing and well-documented Straumann Tissue Level implant[53] (Fig 5-5). They concluded that the adaptation of bone to the most coronal portion of the implant threads is predictable. Three different diameters of the TLX implant were compared to the TL implant, with equivocal results (Fig 5-6). Both implant types displayed noninferior and equivalent levels of osseointegration and bone height maintenance, while the test implants displayed significantly higher primary implant stability. The combination of observations indicates that the novel implant type is able to provide high levels of primary stability combined with a comparable osseointegration pattern to the benchmark TL implants.

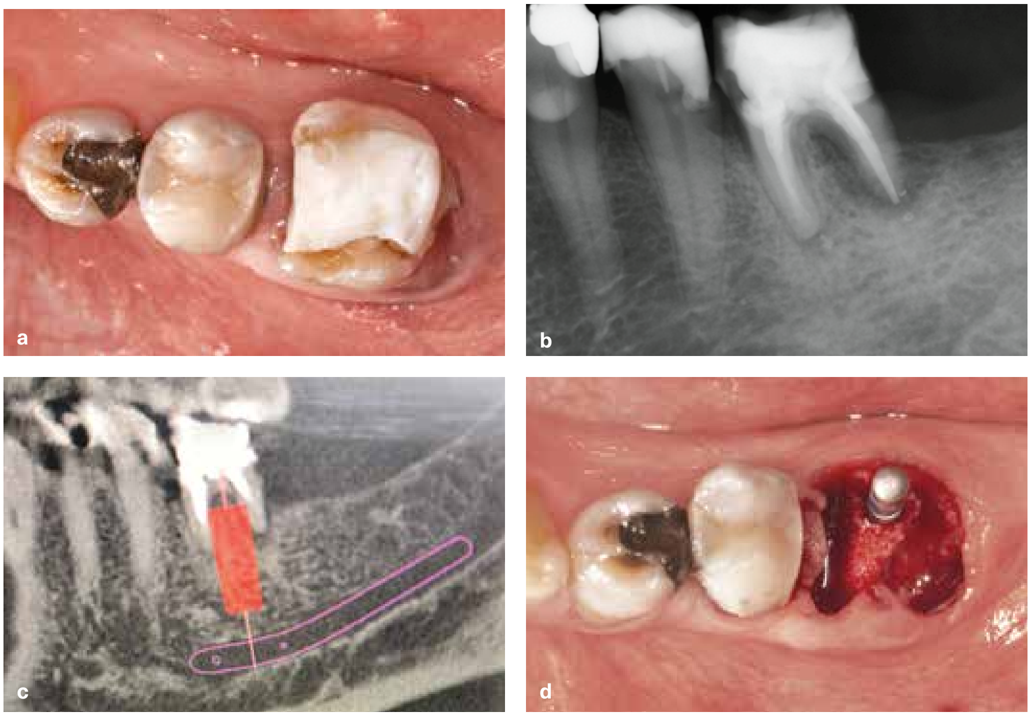


FIG 5-7 *(a)* Nonrestorable mandibular left first molar. *(b)* There is adequate bone volume for an immediate TLX. *(c)* Digital planning for placement of an immediate TLX implant. *(d)* The initial osteotomy is within the interradicular bone. →

Clinical Applications

The following three cases showcase the versatile use of the TLX implant. Case 1 demonstrates the immediate placement of the TLX implant in a molar extraction site. Case 2 introduces guided TLX implant placement, and case 3 involves extraction, simultaneous sinus grafting, and the TLX implant placement for a maxillary molar.

Case 1: Immediate TLX

A 63-year-old woman presents with a nonrestorable mandibular left first molar (Figs 5-7a and 5-7b). After an extensive consultation with the presentation of alternative restorative options, including *(1)* no further treatment after the extraction, *(2)* use of a removable partial denture replacing the molar, or *(3)* an immediate implant if appropriate intraoperative insertion torque was achieved, the patient requested the immediate implant option.

Planning of the placement of a TLX implant was completed in the coDiagnostiX (Straumann) planning software (Fig 5-7c). Careful extraction of the molar was performed, ensuring the preservation of the intraradicular bone (Fig 5-7d). A 4.5 × 12–mm TLX implant was placed with over 30 Ncm of initial stability (Fig 5-7e). The closure cap was placed, and the soft tissue was sutured using a resorbable suture (Fig 5-7f). The postoperative panoramic radiograph shows placement of the implant as planned in the coDiagnostiX software (Fig 5-7g).

After a 3-month osseointegration period, the implant was confirmed to be stable and ready for restoration (Fig 5-7h) .The 11-month clinical and radiographic evaluation demonstrates stable hard and soft tissue volume and position (Figs 5-7i and 5-7j).

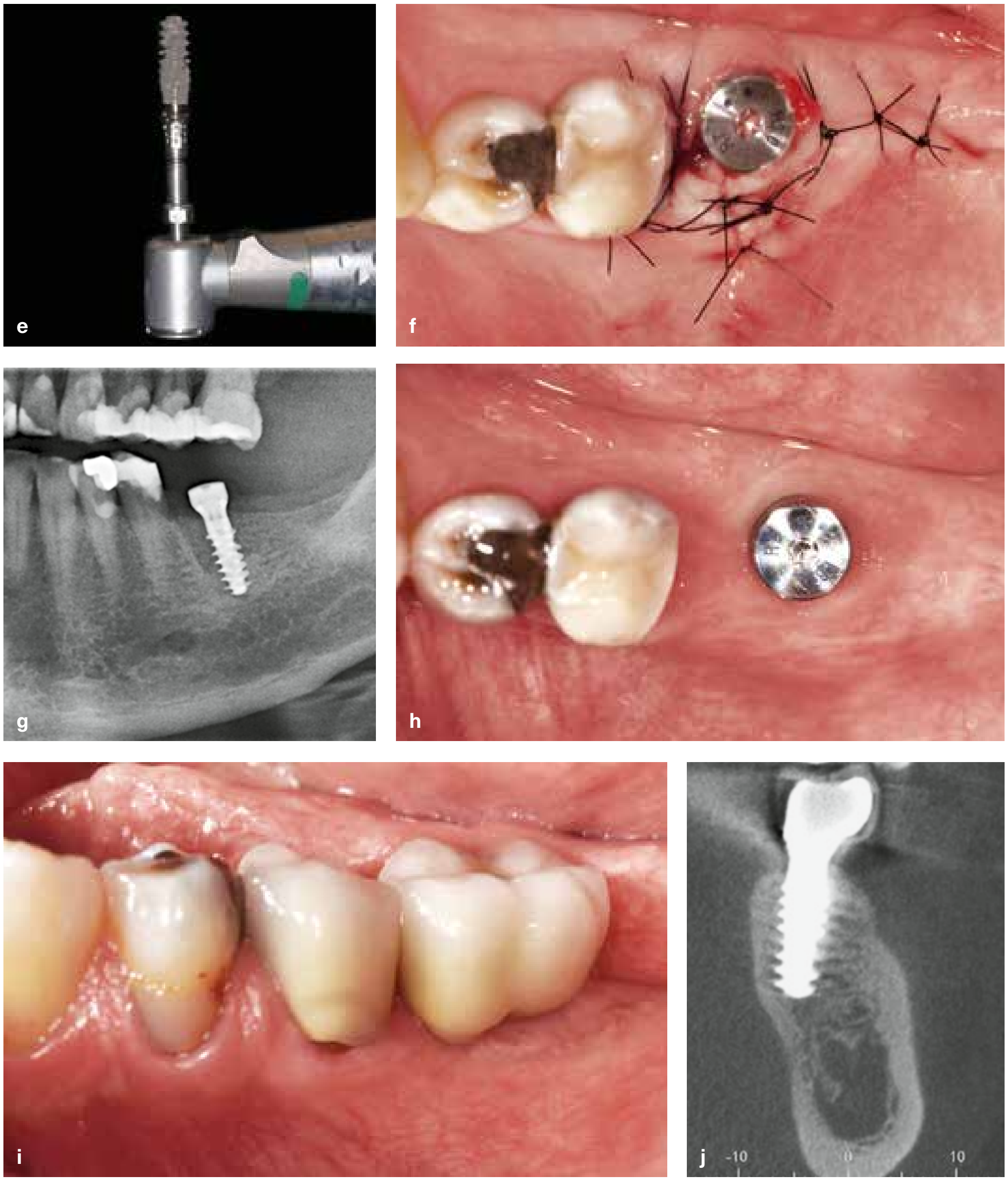


FIG 5-7 *(cont)* *(e)* The 4.5-mm-diameter TLX implant. *(f)* Closure cap in place. *(g)* Immediate postoperative panoramic radiograph. *(h)* Proper healing of the soft tissues around the TLX abutment. *(i)* Definitive screw-retained crown. *(j)* Stable marginal bone levels.

Case 2: Guided TLX

A 64-year-old man presented with missing mandibular left first molar (Fig 5-8a). Guided surgery for the placement of a TLX implant was planned in the coDiagnostiX software (Fig 5-8b). A tooth-borne surgical guide as well as an immediate provisional restoration were printed in preparation for the procedure (Fig 5-8c). With the use of the tooth-borne implant guide (Fig 5-8d), a 4.5 × 14–mm TLX implant was placed at 50 Ncm insertion torque (Fig 5-8e).

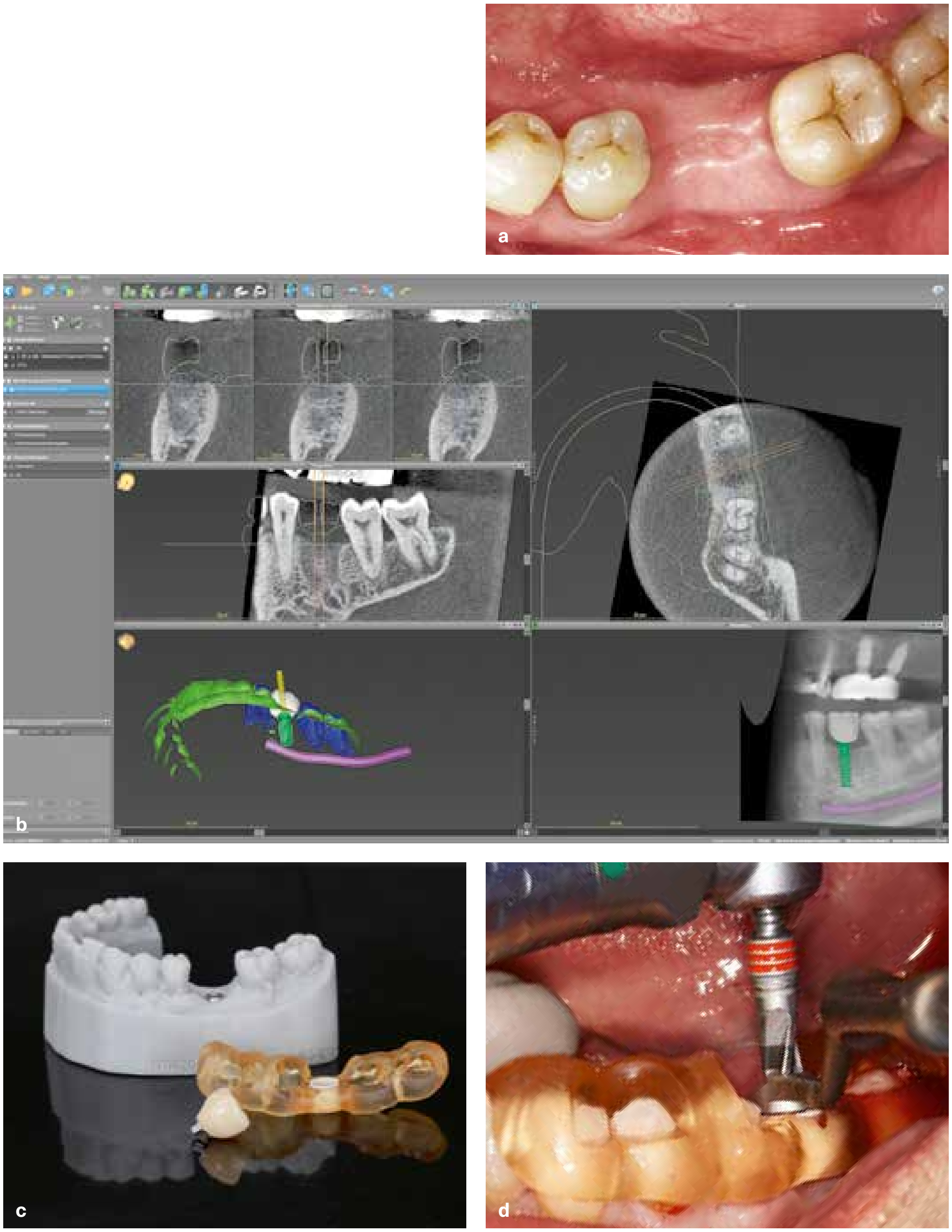
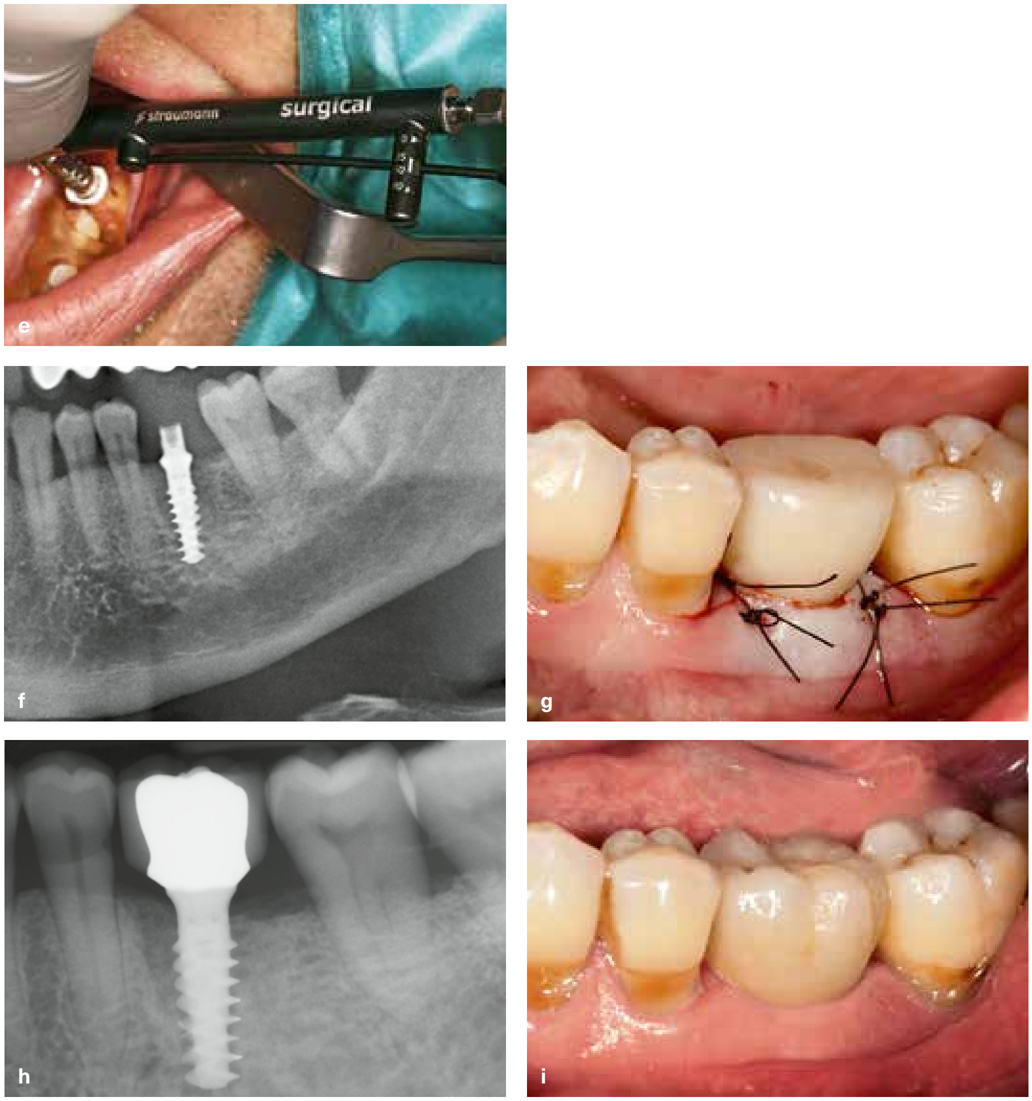


FIG 5-8 *(a)* Missing mandibular left first molar. *(b)* Digital planning for guided surgery with TLX implant. *(c)* Tooth-borne guide and prefabricated immediate provisional. *(d)* Guided implant placement.

FIG 5-8 *(cont)* *(e)* Implant placed with 50 Ncm of insertion torque. *(f)* Immediate postoperative radiograph. *(g)* Immediate provisional secured. *(h)* Complete seating of the components with stable marginal bone levels. *(i)* Stable soft tissue levels with the definitive restoration in place.



The immediate provisional restoration was secured to the implant, and a postoperative panoramic radiograph confirms proper implant placement as well as the complete seating of the immediate provisional prosthesis (Figs 5-8f and 5-8g).

The 12-month panoramic radiograph demonstrates a stable marginal bone level (Fig 5-8h). The intraoral examination is consistent with a stable buccal free gingival volume and height without “showing” of the top of the one-piece implant (Fig 5-8i).

Case 3: TLX and simultaneous sinus graft

A 65-year-old woman presented with a vertical fractured mesial root of the maxillary left first molar at the trunk level (Fig 5-9a). After atraumatic extraction of the molar, crestal sinus elevation was performed (Fig 5-9b) prior to the placement of a 4.5 × 10–mm TLX implant (Figs 5-9c and 5-9d). At 5 months, the implant was restored with definitive screw-retained restoration. Stable hard and soft tissue levels are observed (Figs 5-9e and 5-9f).