From the earliest attempts to successfully design and place dental implants, immediate loading and function have been hallmarks of treatment. Abundant failures in the early developmental stages of implants were commonplace and often occurred immediately or after a short period of functional loading. In many cases, patients were left with clinical problems more severe than their original edentulism. Although those early failure rates were unacceptable by today’s standards, many cases did survive and provide long-term support for functioning prostheses.

Retrospective analysis of those early, immediately, or provisionally loaded implants allows us to now understand why so many of those cases were successful and why others were not. For example, the successful biologic use of metals was highly limited until the development of clean surgical techniques and antibiotics in the nineteenth century. Early experimentation with various implant materials showed that the necessary characteristics of tissue compatibility, corrosion resistance, and strength could not be entirely met in all metals. Gold, silver, and platinum were tissue compatible and corrosion resistant, but lacked strength under high stress. Metals that provided better strength, such as brass, copper, and steel, had poor tissue compatibility and corrosion resistance.

During the 1930s, the first surgical implants were stainless steel alloyed with 18% chromium and 8% nickel, which had good corrosion resistance and strength and were well tolerated by the body. Molybdenum, added later, improved corrosion resistance and formed the basis of an alloy (i.e., Type 316L) commonly used today for orthopedic implants. During the same decade, an alloy used for casting dental appliances, cobalt chromium-molybdenum, was also used for surgical implants.

Corrosion or mechanical failure, such as wear, fretting, and fatigue of coatings, can release particulate debris capable of eliciting both local and systemic biologic responses. Metals are usually not tolerated in large amounts by the body. The ideal implant material would have to be passive to prevent an immunologic response and inert to resist corrosion that could harm local tissues and organs and compromise the long-term functioning of an implant in the biologic environment. Furthermore, the ideal implant material should not yield during insertion, fracture, or fatigue or otherwise fail during in vivo use. Therefore, an implant material’s intrinsic properties of elasticity, yield point, ultimate tensile strength, compressive strength, fatigue strength, hardness, and corrosion behavior must be appropriate for the function it is called to perform.

In 1940, Bothe et al. experimented with the surgical use of titanium and first reported its extreme biocompatibility. It was not until the 1950s, however, that research by Gottlieb and Leventhal and Clarke and Hickman documented titanium’s superior ability to withstand corrosion and remain relatively inert in the body. In the mid-1960s, Branemark et al. reported that ordered, living bone forms a direct structural and functional connection with a load-carrying titanium implant in the process that we now call “osseointegration.”

The modern understanding of biomaterials, implant surface textures, bone physiology, biomechanical loading and/or function, and the systemic health of patients thus enables clinicians to achieve high survival rates and long-term predictability in implant placement. Armed with this knowledge, selecting patients appropriate for immediate functional implants offers advantages, including shorter total treatment time, improved stabilization of hard and soft tissue anatomy, fewer patient visits, and an overall increase in patient comfort and function over a traditional two-stage approach.

Today, with the use of exceptional diagnostic information and sophisticated radiographs, such as CT scanning and computerized analysis programs, the unknowns of the anatomy and bone quality are no longer left to assumptions. Reformed three-dimensional views, anatomic models, surgical guides, and presurgical prosthetics can help ensure that implants placed into immediate functional loading are able to achieve aesthetic results and long-term survival rates that equal or surpass implants placed according to the standard, two-stage surgical approach.

### HISTORY OF IMMEDIATE LOADING

As we look back into the history of dental implantology, we see a natural progression from immediate functional loading to predictable two-stage procedures and the concept of how to achieve and maintain osseointegration. Now we see a return to immediate functional and provisional restoration when patient criteria are well suited to achieve osseointegration, predictability, and healthy, stable, and maintainable aesthetic results (Box 32-1).

In 1937, Dr. Alvin Strock, a Boston oral and maxillofacial surgeon, placed an orthopedic bone screw into an immediate extraction site of a periodontally involved mandibular
Implants placed in subsequent years had a variety of shapes, designs, materials, and techniques for placement. One common procedure, however, was that many of these implants were placed and restored according to a one-stage procedure that included direct impressioning and rigid splinting of the implants with provisional restorations at the time of surgical placement (Figure 32-3).

Early, well-documented studies of the titanium plasma sprayed screw (TPS), developed by Dr. P. Ledermann in the 1960s, showed that by following basic biologic and biomechanical principles immediate provisional function of implants could be achieved (Figure 32-4). It was recognized that the selected biomaterial, a roughened TPS implant, placed in a dense bone osteotomy that had been prepared slightly undersized resulted in gentle compression of the bone and excellent initial implant stability. The protocol required that four implants be placed in the anterior mandible between the mental foramina to allow adequate support for an immediate repair.
 start the prosthetic reconstruction of the case while the patient continued to undergo osseointegration enhances the second-stage procedure by having the final abutment and anatomic restoration ready to be placed. For the first time, certified laboratory technicians were given information from these primary impressions that had not been available from traditional, second-stage impressions. We know from a number of studies how important knowing the level of the osseous crest is to the contact points of teeth for interdental papilla support, formation, and maintenance. With an immediate impression, this information is now visible and available on the master cast.

There are several materials available when choosing an impression material for use in immediate impression taking. The use of polyethers, silicones, and polysulfides is preferable as a result of their durability and rigidity. These materials aid in avoiding flexion upon removal and help prevent positional distortion. Other factors contributing to selection are material accuracy, working time, ease of handling, and physician experience.

Polysulfide rubber base impression materials exist in three phases: light, regular, and heavy bodied, based upon their viscosity and ability to flow under loading. The base material consists of 80% low-molecular-weight organic polymer, containing reactive mercaptan groups and 20% reinforcing agents, including titanium dioxide, zinc sulfate, copper carbonate, or silica. The catalyst is usually lead dioxide, which functions as an accelerator.

Silicone impression materials exist as two types: condensation and addition. The condensation type is composed of a base and a catalyst. The base consists of dimethylsiloxane paste, a relatively low-molecular-weight silicone liquid. The catalyst is made up of a tin organic ester suspension and an alkyl silicate in liquid form. The addition type is usually a two-paste or two-putty combination. Included in the reaction are a low-molecular-weight silicone with terminal vinyl groups, filler for reinforcement, and a chloroplatinic acid catalyst together with low-molecular-weight silicone with saline hydrogens and reinforcing filler.

Polyether rubber base impression materials also exist as base and catalyst reactions. The base is usually a low-molecular-weight polyether with ethylene imine terminal groups. An aromatic sulfonic acid ester catalyst causes a reaction among the terminal groups forming cross-linked high-molecular-weight rubber.

The choice of impression material is usually made by examining their properties. All of the previously mentioned impression materials provide excellent reproduction of detail. Condensation silicone and polyether materials have shorter working times, whereas addition silicone is slightly longer and polysulfide longer still. Polyether materials have the shortest setting time, whereas addition and condensation silicones are moderate, and polysulfide has the longest setting time. Flexibility on removal from lowest to greatest is: polyether, addition silicone, condensation silicone, and polysulfide. Polysulfide materials have the highest tear strength followed by addition.
silicones, condensation silicones, and polyether. All of these impression materials possess adequate properties to be used as impressions for dental implants. The choice is usually made based on ease of use, cost, and physician comfort with the material.

Day-of-surgery impressions and indexing can allow for placement of the final restoration earlier in the healing period after implant integration. These immediate impressions are also useful in CAD/CAM technology for creating custom abutments. There are several implant impression techniques. The more common techniques are direct, indirect, and direct-splinted. The majority of the current literature suggests that a direct technique is the most accurate, whereas indirect is the least accurate. Whether or not to use a custom tray or stock design for implant impressions is usually based on the material used and the discretion of the practitioner. A similar decision-making process determines the use of an open-tray or closed-tray technique. Open-tray technique is advocated for multiple splinted restorations because of its increased accuracy in these cases.

Once the implant has been placed, impression material chosen, and the transfer post applied, the impression may be taken. Closure of open gingival flaps is not required, although it is imperative that all impression material be removed before closure to prevent foreign body reaction. An adhesive is applied to the impression tray and allowed to dry for the specified time. Care is then taken to insert the impression tray, which is held with gentle pressure until the impression material is primarily set. The tray and impression material are removed ideally in one motion to prevent excessive distortion of the material. Casts are then made using dense stone, and the implant analogs are used for creation of either a temporary or permanent restoration.

Whichsoever technique is chosen, impressions at the time of implant placement provide the laboratory technician with the information to create appropriate emergence, gingival contour, and aesthetic form. Recognizing the importance of having this information and the demonstrated effect of immediate function, the placement of an impression post allows the implant surgeon to make an impression of the implant immediately after placement for the fabrication of provisional or definitive abutments and provisional prostheses (Figure 32-5 A-G). Zimmer Dental, Inc. has incorporated a premounted fixture mount transfer pin in its product line. This feature allows for implant placement and impression taking to occur without changing any parts on the implant (Figure 32-6 A-E).

**IMMEDIATE PROVISIONALIZATION**

Provisionalization of implants on the day of surgery has been reported with high success rates. Prior technique recommended a healing time of 4 to 6 months before functional loading. Immediate provisionalization allows the patient to return to proper form and satisfies the patient’s desire to maintain aesthetics. The goals of immediate provisionalization of implants include: maintaining interdental space, development of the gingival sulcus contour, minimizing delay in final restoration, elimination of second-stage surgery, and avoidance of a temporary removable appliance.

Provisionalization encompasses the majority of the implant process. The physician must choose the use of a temporary or permanent abutment, what type of abutment to use, and the mechanism by which to provisionalize. The use of a permanent abutment at the time of immediate provisionalization obviously requires either predesigned and meticulously planned implant placement guiding systems or an in-house or nearby laboratory with which the restorative dentist would work closely. The lab may also fabricate a provisional restoration for placement, or the provisional restoration may be created by the practitioner using either a prefabricated shell, custom mold, or block carve techniques. Regardless of the technique chosen, the importance of proper occlusal adjustment with immediately loaded implants is paramount.

Several abutment systems exist for provisionalization of dental implants. The restorative dentist must choose between custom, stock, and computer-designed and computer-generated abutments. Computer-aided design and computer-aided manufacturing (CAD/CAM) is gaining in popularity as a result of the elimination of laboratory fabrication. The CAD/CAM technology was expanded to include abutment fabrication for dental implants in the 1990s. Stock or cast custom abutments have been incorporated in implantology since its inception. They are available in titanium, noble metal alloys, and ceramics. The primary difference between stock and cast custom abutments is the need to prepare stock abutments.

Advantages of stock abutments include lower cost, preparation is intraoral or extraoral, and potentially minimal preparation time. Intraoral preparation adds additional disadvantages to stock abutments, including the need for patient anesthesia, gingival retraction, and risk to adjacent structures. The major disadvantage of stock abutments is their cylindric shape. This requires the addition of antirotation grooves that may compromise strength. The cylindric shape also prevents the emergence profile from beginning at the implant platform and must begin at the prepared edge of the abutment. Abutments with fixed angulations often do not match the exact angulations needed, and additional preparation is required.

Cast custom abutments solve some of the problems of stock abutments in that they are produced specifically to replace the lost structure. The transition of the abutment begins at the implant surface, thereby improving the emergence profile and overall aesthetic results. The disadvantages to cast custom abutment include the high cost of fabrication, the dependence on the technician for design and contour, and the potential for voids inherent in the investment, casting, and finishing process.

The technologic advancements in CAD/CAM design avoid the assembly line nature of both stock and cast abutments. They provide an abutment design specific to the individual (Figure 32-7 A, B). The technician learning curve is assisted by software design allowing virtual creation of the abutment before computer-assisted milling. This allows for the elimination of most of the dimensional inaccuracies inherent
SECTION IV  ■ Implant Surgery

FIGURE 32-6.  A, Implant fixture mount transfer abutment. B, Transfer impression with analog in place. C, Immediate temporary provisional restoration. D, Immediate provisional restoration in place. To view a color version of this illustration, refer to the color insert section at the back of this book.

in the casting process. The CAD/CAM process is especially beneficial in using titanium abutments producing a more homogenous result with optimal material properties. Even when laboratory steps are followed, the heat-induced changes occurring during casting reduce the contact between abutments and their retaining screws. Because CAD/CAM abutments do not require manipulation after production, they provide the potential for superior fit, allowing for increased precision. The overall cost of CAD/CAM abutment systems remains high; however, the initial monetary commitment may be distributed over the number of abutments used.

Provisionalization at the time of surgery provides several benefits. First, the periimplant tissue is contoured to the expected profile of the final restoration (Figure 32-7 C-F). This allows for maturation of the attached tissue to occur with the minimal need for manipulation upon delivery of the final restoration. Overdentures and temporary fixed appliances may be created on the day of surgery by in-house or nearby laboratories, when available, and attached to these implants before the fabrication of the final restoration. The principles of occlusion must be followed in the creation of these temporary restorations. Abnormal distribution of the occlusal forces may lead to implant and case failure. Lateral excursive forces and excessive contact in centric occlusion produce forces off the implant axis. Ideally, occlusal forces should be directed along the long axis of the implant.

The concepts of bone level impressions, immediate provisionalization, and immediate loading of implants may be combined to allow for maximum patient benefit. The surgeon, restorative dentist, and laboratory technician work in unison to provide restoration of form and function in a timely manner. Several versions of this philosophy have been advocated. One such combination and treatment pathway will be described.

### SMARTSTEPS: THE CONCEPT

Primary impression taking, immediate restoration, and immediate functional loading are a treatment philosophy that offers tremendous benefits to the surgeon, restorative dentist, laboratory technician, and ultimately the patient. It is a set of bundled surgical and prosthetic techniques that also takes the complexity out of implant restorations.

Why do SmartSteps?
- Benefits to the surgeon
- Increase patient referrals
- Benefits to the restoring physician
- Reduced chair time
- Simple implant cases
- Increased patient acceptance
- Benefits to the patient
- Fewer visits
- Earlier function
- Earlier aesthetics

---

**FIGURE 32-7, cont’d.**

CASE REPORT 32-1  Immediate Impression with Restoration Placed at Second-Stage Surgery

This 47-year-old woman had an endodontically failing mandibular right first bicuspid (#28) that served as the anterior abutment connecting a four-unit fixed partial denture to a distal abutment and a severely decayed mandibular right second molar (#31) (Figure 32-8).

The hopeless abutment teeth (#28, #31) were atraumatically extracted to preserve the bony architecture around the socket. Two 3.7-mm diameter and two 4.7-mm diameter Tapered Screw-Vent implants were placed into the two prepared sockets (Figure 32-9). Impression material was injected around implants with the soft tissue flap open to allow for accurate impressioning of implant impression posts and surrounding osseous crest, soft tissue, and teeth (Figure 32-10).

The laboratory technician was sent the primary impression by the restorative dentist with the appropriate information for the work to be done. The technician was instructed to not be concerned with the lack of soft tissue on the working cast and to fabricate an appropriate definitive abutment. The instructions also included fabrication of the provisional prosthesis and a framework for the definitive crown that directed that the contact point not be more than 5 mm from the osseous crest. A coping could also have been made for the final impression after all functional and aesthetic concerns have been resolved with the patient.

Laboratory work (Figure 32-11 A, B).

- Abutments
- Provisional prosthesis
- Final cast framework for the restoration (no picture available)
- Placement jig for abutments


FIGURE 32-9. Placement of four Zimmer Tapered Screw Vent implants with immediate impression components premounted on the implant. To view a color version of this illustration, refer to the color insert section at the back of this book.

FIGURE 32-10. Polyvinyl impression material injected over impression pins to obtain a bone level impression. To view a color version of this illustration, refer to the color insert section at the back of this book.

FIGURE 32-11. A, B, Laboratory-prepared abutments with placement jig and temporary crowns. To view a color version of this illustration, refer to the color insert section at the back of this book.
At the second-stage surgery, soft tissue-sparing incisions were made to maximize the attached gingival tissue and drape around the aesthetic, anatomic restorations (Figure 32-12).

Final restoration (Figure 32-13) and final Panorex (Figure 32-14).

**FIGURE 32-12.** Minimal incision exposure for placement of abutments and temporary restorations. To view a color version of this illustration, refer to the color insert section at the back of this book.

**FIGURE 32-13.** Final crowns after soft tissue healing. To view a color version of this illustration, refer to the color insert section at the back of this book.

**FIGURE 32-14.** Postoperative panoramic x-ray.
A 41-year-old woman had tooth #11 with significant internal resorption and a poor prognosis. Aesthetic and function were an important factor because of her very high smile line and her need to speak clearly without any removable appliances (Figure 32-15 A, B). The tooth was extracted atraumatically using Periotomes, and the site was grafted before implant-site preparation and insertion (Figure 32-16 A, B). A plastic temporary abutment, which can be very easily prepared, was placed, and an acrylic provisional crown was fabricated (Figure 32-17 A, B). This was very functional and aesthetic, and the final restoration was placed at 3 months (Figure 32-18 A, B, C). Figure 32-18 C shows the provisional restoration at 1 week. The final restoration was fabricated at 3 months.


CASE REPORT 32-2  Immediate Extraction, Implant Placement, and Provisional Restoration—cont’d


CASE REPORT 32-3 | Placement of Implants in the Areas of Teeth #4 and #6 with Placement of Prefabricated Ceramic Abutments and Temporary Crowns Done as a One-Stage Procedure

This 38-year-old woman was wearing a partial denture and requested a fixed bridge to extend from tooth #4 to #6. The residual bone as seen on Panorex was adequate in both height, width, and density for an immediate restoration (Figure 32-19). The model taken was sent to the laboratory for placement of the implant analogs so that surgical guides, final abutments, and a temporary bridge could be fabricated (Figure 32-20 A, B, C). Using the surgical guide, the implants were placed, final zirconia custom abutments secured, and the immediate provisional bridge placed (Figure 32-21 A, B, C). After 3 months of function and soft tissue healing, the final restoration was placed (Figure 32-22). Final Panorex (Figure 32-23).

FIGURE 32-19. Preoperative panoramic x-ray showing adequate bone height in areas in the right maxillary.

FIGURE 32-20. A, Presurgical model preplanned with implants and Procera ceramic abutments. B, Immediate temporary restorations on pre-planned model. C, Surgical guide for implant placement. To view a color version of this illustration, refer to the color insert section at the back of this book.
CASE REPORT 32-3  
Placement of Implants in the Areas of Teeth #4 and #6 with Placement of Prefabricated Ceramic Abutments and Temporary Crowns Done as a One-Stage Procedure—cont’d

FIGURE 32-21.  A, Immediate placement position of 4.3 Nobel Biocare Replace Select implant. B, Ceramic abutments secured and torqued in place. C, Temporary provisional crown ridge spanning teeth #5 through #6. To view a color version of this illustration, refer to the color insert section at the back of this book.

FIGURE 32-22.  Three-month postoperative view with final crown restorations. To view a color version of this illustration, refer to the color insert section at the back of this book.

FIGURE 32-23.  Final 6-month postoperative panoramic x-ray.
When primary stability of the implant is apparent, making an immediate impression has been shown to significantly improve all aspects of the restorative process and enhance soft tissue aesthetics. There is no evidence that making an impression at stage-one surgery in any way impairs the ability of the implant to heal and integrate. Certainly, extreme care is taken to see that all impression material is removed and that proper techniques are executed. The implant must also not be altered in position by rotating it after the impression has been made, when tightening the healing screw, or attaching the abutment. When there is appropriate support of the implant in bone and the restoration can be protected from excessive trauma, the placement of an immediate provisional restoration should be considered. This protection may come from a guarded occlusion provided by adjacent teeth to prevent trauma and/or carefully adjusting the restoration to be in a very light or nonoccluding relationship to the opposing teeth.

REFERENCES