Numerous studies have confirmed the predictability of dental implants used for the replacement of a single missing tooth. Successful application of this surgical protocol is still technique sensitive and should be executed only by experienced restorative teams. Factors such as implant stability, implant design, immediate loading, provisionalization, and various others have a direct influence on the result of this procedure. This article reviews current literature on immediate implant placement and provides clinical guidelines aimed at improving the use of this technique in daily restorative practice.

Key Words: implant, immediate provisionalization, soft tissues, osseointegration, aesthetics
The immediate replacement of a single tooth with an implant is no longer considered an experimental technique. The literature bears witness to numerous reports and clinical studies demonstrating that this technique has been mastered in cases where its indications are properly assessed and its execution is perfectly accomplished. Interest in this technique can be attributed to the following benefits:

- Preservation of tissue and optimization of the soft tissue contour.
- Simplification of treatment and reduction of sequences.
- Improved psychological advantages.
- Enhanced patient comfort and aesthetics.

Nevertheless, this surgical-prosthetic procedure remains technique sensitive and should be implemented only by a well-trained surgical/restorative team. By reviewing literature concerning the essential parameters that are currently under discussion, the authors shall highlight the clinical and practical conclusions involved in optimizing this technique for use in daily practice.

### Loading and Osseointegration

The remarkable success rates reported by longitudinal studies involving one-stage implants (ie, implantation accomplished via one surgical procedure) have eliminated one of the basic tenets of the original Brånemark technique: the covering of the implants, supposedly protecting them against early loads liable to ruin their osseointegration. Clinical studies have demonstrated that these same one-stage implants, when situated in the symphyseal sectors and covered by complete rebased dentures (ie, exerting pressures), had success rates comparable to those of two-stage implants. Clinicians thus recognized that immediate implant loading — when properly implemented in bone of good quality and sufficient implant stability was achieved — did not compromise osseointegration (Figures 1 through 10).

It appears that it is not early loading that creates the effect of fibrous encapsulation, but rather a certain degree of micromovements at the bone/implant interface resulting from inadequate primary stability. Various experimental studies indicate that the range of tolerance of these micromovements is approximately 50 \( \mu \)m to 150 \( \mu \)m for rough surfaces and about 100 \( \mu \)m for smooth machined surfaces. Thus, the implant surface is not an indifferent factor in the process of bone healing. Rough surfaces appear to tolerate greater micromovements and therefore could be placed under load at an earlier time.

In light of these data and numerous clinical studies (Glantz, Randow, Chiapasco, Balshi-Wolfinger, Tarnow), immediate or early loading can be legitimately considered for cases with dense bone and when the implants are splinted. For its part, the “pseudoloading” of a single-tooth restoration in the aesthetic zone essentially requires perfect primary stability and complete occlusal arch support, which, in the absence of splinting, alone guarantees limited micromovements within the limits of tolerance.
The Factors of Primary Stability

Microscopic study of the bone/implant interface reveals that this coadaptation does not result from a “chemical bond.” The stability of an implant depends almost exclusively on the mechanical interlocking between the mineralized bone and the roughness of the implant surface. The obtaining and the optimizing of this interlocking involves a certain number of factors that include the bone factor, the implant design, and the surgical protocol.

The Bone Factor

Chemical studies have clearly shown the relationship between primary stability and bone density, as evaluated by the drilling torques. In dense bone, the process of osseointegration does not modify implant stability, since primary stability was very good during stage I surgery. Since osseointegration is no longer a prerequisite for the prosthetic phase, early loading may be justified in these cases, thus reducing the length of treatment.

Alternately, the stability of implants placed in bone of less density is inadequate, and it will be necessary to lengthen the period of healing beyond the norm.

Osseointegration and subsequent loading increase this secondary stability, eventually raising it to a quality comparable to that of dense bone. It is thus essential to be able to identify, during preimplant study and surgery, the qualitative bone factors (e.g., height, volume, density, thickness of the cortical plates) by tomodensitometric radiological examination (i.e., CT scans). It is similarly imperative for clinicians to understand the values of the implant insertion torque, in order to determine the need for osseointegration and the ideal duration for it.

The Implant Design

Since primary stability depends directly on the contact surface between the implant and the bone, various morphological features have been recommended. These include the taper or “anatomical shape” of the implant body, so as to compress bone of lesser density (Replace, MkIII, MkIV, Nobel Biocare, Yorba Linda, CA; Frialit-2,...
shown that the primary stability increases in proportion to the insertion torque, thus enhancing the implant’s resistance to micromovements. For an early loading, minimum insertion torques of 35 Ncm through 50 Ncm have been proposed.

Objective Evaluation of Implant Stability
This evaluation has long been considered subjective, since it is not based on quantitative methods: dental radiographs, percussion, resistance to screwing. Based on the studies of Meredith on the resonance frequency analysis (RFA), clinicians now have an objective and quantitative method for assessing the stability and the osseointegration of implants. This process measures stability by the application of microscopic flexural stress (most often functional clinical stresses undergone by implants).

The Surgical Protocol
In order to improve the implant stability when installing the implant, various techniques have been proposed, particularly in bone of lesser density that often occurs in the premaxilla. One involves the “undercalibration” of the implant site via insertion of a self-tapping implant; a second uses the osteotome technique, either by itself or as a supplement to conventional drilling, to compact cancellous bone and improve its density.

The use of root form implants (e.g., Replace, Nobel Biocare, Yorba Linda, CA; Frialit-2, Friatec, Irvine, CA) is based on the same principle, that is, with the objective of laterally compacting the cancellous bone. It has been shown that the primary stability increases in proportion to the insertion torque, thus enhancing the implant’s resistance to micromovements. For an early loading, minimum insertion torques of 35 Ncm through 50 Ncm have been proposed.

**Table**

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<th>ISQ</th>
<th>Clinical Translation</th>
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<td>&lt; 50</td>
<td>Insufficient Stability</td>
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<td>&gt; 60</td>
<td>Excellent Stability</td>
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*For Replace (Nobel Biocare, Yorba Linda, CA) implants.

Figure 10A. Preoperative radiographic evaluation demonstrates the position of the fractured lateral incisor requiring extraction. 10B. Immediate postoperative radiograph demonstrates implant placement (Replace Select, Nobel Biocare, Yorba Linda, CA).
After stimulating the transducer, the resonance frequency of the system is recorded. This value is influenced by the characteristics of the implant, the bone volume, the bone quality, and — in particular — by the degree of rigidity at the bone/implant interface. The RFA will be able to evaluate the stability after installation of the implant as well as following osseointegration; it also monitors the decrease in rigidity at the bone/implant interface over time, thus allowing one to anticipate a possible implant failure even prior to its radiographic manifestation. This is a determining factor in clinical evaluation and the decision-making process, indicating, for example, whether the implant can be early loaded or whether it should be submerged and undergo a longer period of healing. In the Osstell system, resonance frequency values have been translated into an index known as the Implant Stability Quotient (ISQ), which is easy to use in clinical practice and numbered from 0 to 100 (Table).

**Clinical Considerations**

**Guidelines For Immediate Implantation**

It is clear that immediate implantation can no longer be considered as an experimental technique. Numerous studies show medium- and long-term survival rates comparable to those for conventional techniques involving delayed implantation. The clinical parameters (eg, appearance of tissues surrounding the implant, bleeding, probing) and histological parameters also demonstrate an identical appearance to those of delayed implants. One of the principal advantages of the immediate technique is the prevention of postextraction bone resorption. According to Carlsson, this bone loss may affect approximately 23% of the anterior alveolar crest during the six months following extraction. The literature highlights additional clinical parameters required to optimize the potential for success:

- **Infection**, possibly affecting the root being extracted, would represent a contraindication to the technique, as it is most often accompanied by apical or lateral bone loss that might impair primary stabilization and healing. It is important to evaluate the presence of this by clinical (eg, pain upon percussion, presence of exudate, fistula) and radiographic criteria. Chronic infection or granuloma without major bone loss might be acceptable in limited cases.

- **The depth of osteotomy**: It seems logical to insert an implant of sufficient length to ensure the best possible quality of anchoring. In any case, there seems to be a consensus in having the drilling limit at a minimum distance of 3 mm to 5 mm beyond the apical limit of the

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**Figure 11.** Case 2. Preoperative view following trauma and fracture of the incisor’s root. Coronal fractures were also evident on the adjacent teeth, and the teeth were splinted together.

**Figure 12.** Flapless surgery was conducted, the implant was positioned, and chairside adjustment and connection of the sandblasted abutment was performed.

**Figure 13.** Margins were refined on the analog in order to allow optimal precision and emergence profile.
extracted tooth root in order to ensure sufficient primary stability. There appears to be a consensus for an implant length of 12 mm to 13 mm for the maxillary incisors, for example.

- The gap that may remain between the cervical portion of the implant and the surrounding alveolar rim does not appear to require systematic filling, provided it does not exceed a value of approximately 1 mm. In this regard, the use of a wide implant (at least in its crown portion) is desirable. The selection of an overly wide implant may, however, eventually result in resorption of the interdental crestal bone with aesthetic repercussions. The minimum space between an implant and a natural tooth should remain 1.5 mm to 2 mm (Figures 11 through 18).

- The surgical technique: Raising a surgical flap compromises the bone vascularization and may result in marginal bone loss and soft tissue recession with collapse of the interdental papillae, particularly in the presence of thin, scalloped gingiva. Gomez-Roman demonstrated that a narrow mucoperiosteal flap preserving the papillae would produce considerably less significant crestal bone loss than a broad flap involving the entire papilla. Thus, placement of an implant without flap elevation would minimize tissue loss. The lack of visibility of the bone site should, however, be compensated for through preoperative planning and CT scans. The success of this flapless technique depends on the clinicians’ adherence to a particular protocol:
  - Alveolar crest with minimum thickness of 6 mm.
  - Prudent extraction.
  - Use of a surgical guide to compensate for the lack of vision.
  - Drilling of the implant site guided by surgeon’s finger, which is placed on the buccal gingival wall to prevent possible perforation.
  - Use of the palatal wall as a drilling guide.
mean values of less than 5 mm for natural teeth and 8 mm to 9 mm for the implants. It is the level of this interdental crestal bone that is crucial to the preservation of the papillae. The “microgap” corresponding to the prosthetic joint (ie, cervical limit of the abutment) should be located at a minimum distance of 2 mm from the bone crest to allow the “biologic width” to be established.33

Immediate Replacement
Research on the preservation of the tissue architecture, the reduction of surgical sequences, the augmentation of patient comfort during provisionalization, and greater aesthetic requirements31 have led many practitioners to consider immediate replacement of the missing or freshly extracted tooth. Studies and clinical reports alike demonstrate the increasing interest of dental professionals in this technique for the aesthetic zone.34-37 These various studies allow the authors to develop and to present a set of criteria for evaluation and implementation that should be rigorously followed to optimize the chances for success of the technique.
One point of discussion concerns the decision to treat healed sites or fresh sockets. In a retrospective study of five years (with an average real clinical perspective of 24 to 30 months) involving 233 implants, an overall success rate of 95.5% was presented. All failures involved extractions with immediate implant placement and were attributed to either infection of the extraction site or insufficient primary stability. The authors confirmed that predictability of the treatment was greater in healed sites versus fresh sockets, as did Malo et al who also found that failure was due primarily to the infection of the extracted teeth. Although the occlusal contacts had been eliminated, Malo et al also observed several crown fractures, which indicated that there are certain constraints on these restorations during provisionalization and that primary stability was critical to success.

Choquet et al used a specific surgical technique in which all the implant sites (n = 37) were systematically prepared with the combination of 2-mm pilot drills and Summers osteotomes. All the implants were inserted with a minimum torque of 40 Ncm. The results of this prospective study at one year revealed two early failures in premolar sites, probably due to the use of implants with inappropriate morphology for the site (MkIII in a bone of low density and MkIV in a dense bone) (Figures 19 through 24).

Hui et al present a preliminary report (13 to 15 months) of a prospective study involving 24 single-tooth implants. No implant was lost during this period. No implant underwent marginal bone loss greater than 0.6 mm. It was not possible to find any difference between the healed sites and the immediate implantations. All the implants were installed by finding a bicortical anchoring with a minimum controlled insertion torque value (40 Ncm to 50 Ncm) to ensure an optimal primary stability. The authors concluded that absolute control of the primary stability was imperative to the success of the procedure.

**Clinical Implications**

It follows from this analysis that objective control of implant stability (eg, via RFA), in combination with the application of a controlled insertion torque, is essential for confirming the possibility of immediate replacement as early as the installation of the implant. Furthermore, it seems advisable that, whenever technically possible, the implant should be splinted with the adjacent natural teeth in order to limit micromovement at the bone/implant interface. The connection to two or three adjacent teeth on each side of the implant, with fibers and composite, for example, significantly reduces the physiological lateral mobility of a periodontally healthy natural tooth, which lies in the range of 56 µm to 108 µm. The containment, besides its effect of distributing the stresses among all the solidified elements, has the advantage of changing the orientation of the stresses. The direction of a lateral constraint gradually approaches that of the major axis of the teeth when its surface of application becomes more extensive.
Conclusion
In a previous article on the immediate replacement of a single tooth, the authors wrote: “Since the maintenance of the existing anatomical structures is easier than their re-creation, it has even been advocated to perform pro-
visionalization with a pseudo-loaded prosthesis immediately following stage I surgery in immediate tooth replacement although this procedures is still experimental.” Immediate replacement, while no longer experimental, nevertheless remains challenging and requires careful case selection (i.e., preimplant identification of unfavorable factors), a rigorous observance of the criteria for success, flawless technical execution, serious collaboration with the patient, and strict professional maintenance.

Long-term multicenter prospective studies would be useful in confirming the reliability of the technique, identifying factors to optimize it, and to define its limitations. The evolution toward the combination of immediate implantation and early loading techniques, however, appears to represent the most adequate solution for solving concerns inherent in single-tooth replacement for the aesthetic zone. Progress in the areas of implant design (i.e., scalled neck), surgical technique, and strict control of the implant stability will help further increase the reliability of this technique.

References
1. According to the Osstell system, the ISQ defines insufficient stability as:
   a. Less than or equal to 25.
   b. Less than 50.
   c. Less than or equal to 60.
   d. Greater than 60.

2. Which of the following is a benefit of immediate implantation with provisionalization?
   a. Improved psychological advantages.
   b. Preservation of tissue and optimization of the soft tissue contour.
   c. Enhanced patient comfort and aesthetics.
   d. All of the above.

3. The degree of tolerance of micromovements at the bone/implant interface is:
   a. 100 µm for smooth surfaces, 50 µm to 150 µm for rough surfaces.
   b. 50 µm for smooth surfaces, 25 µm to 125 µm for rough surfaces.
   c. 150 µm for smooth surfaces, 100 µm to 200 µm for rough surfaces.
   d. 75 µm for smooth surfaces, 50 µm to 200 µm for rough surfaces.

4. Which cases can be considered for immediate or early loading?
   a. Cases with splinted implants and poor bone density.
   b. Cases with dense bone only.
   c. Cases with dense bone and splinted images.
   d. Cases with splinted implants only.

5. According to microscopic study, the coadaptation stability of an implant depends on:
   a. The interlocking between mineralized bone and the smoothness of the implant surface.
   b. The interlocking of a chemical bond.
   c. The interlocking between the roughness of the implant surface and the mineralized bone.
   d. The interlocking of the implant surface to a chemical bond.

6. During the period of provisionalization, the soft peri-implant tissues are subject to recession of approximately:
   a. 0.6 mm to 1.1 mm.
   b. 0.6 mm to 1 mm.
   c. 0.9 mm to 1.4 mm.
   d. 0.9 mm to 1.1 mm.

7. According to the literature, which clinical parameter can reduce the potential for a successful immediate implantation?
   a. A deep osteotomy.
   b. Placement of an implant without flap elevation.
   c. A gap greater than 1.5 mm between the implant and the alveolar rim.
   d. None of the above.

8. The physiological lateral mobility of a periodontally healthy natural tooth ranges from:
   a. 55 µm to 110 µm.
   b. 59 µm to 109 µm.
   c. 56 µm to 108 µm.
   d. 50 µm to 100 µm.

9. According to the literature, how long should the temporization period be observed proceeding the final restoration?
   a. At least six months.
   b. More than six months.
   c. At least five months.
   d. More than five months.

10. According to the author, the implant should be splinted with the adjacent natural teeth in order to limit micromovement, whenever technically possible, at the bone/implant interface.
    a. True.
    b. False.