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Zur Frage der Sofortbelastung von frisch inserierten Schraubenimplantaten
Der Sofortsteg unter spezieller Berücksichtigung des SPI®-Konzepts

Author: Philippe D. Ledermann and Daniel Megert, Bern

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Immediate Loading of Freshly Inserted Screw Implants

The immediate bar with special consideration of the SPI® concept

Philippe D. Ledermann and Daniel Megert

It took a quarter of a century from 1977, when the first author of this paper demonstrated and recommended immediate loading of osseointegrating screw implants, for the concept to be accepted. Despite a number of arguments and unproven counter-assertions, not least from University departments, immediate loading has recently become the therapy of choice. Is this related to the recent insight that bones only achieve optimal reparative ability under functional-dynamic conditions, or because of practical experience with this phenomenon obtained by the major expert in this field, or because of a quiet shift in scientific paradigm? We report here the long-term results of immediate loading using immediate bars on screw implants over a period of almost 30 years, and explain the development of the Ledermann screw culminating in the current SPI® concept.

The first immediate loadings

From 1975 to 2002, 5647 screw implants were inserted in 1656 patients. Of these, 1968 implants with 501 immediate bars were subjected to immediate functional loading. The loss rate for bar implants was 5.79%. The oldest immediate bars have functioned for 28 years. Until 1977 we used CBS® screws, until 1986 TPS® and NLS® screws, and from 1985 Ha-Ti® or SPI® implants. All implants were documented radiologically and photographically, and recorded and evaluated using the implant databank of Bleymüller, IDB (1994). The initial experience with immediate bars was obtained with CBS® screws in the interforaminal region of the edentulous mandible. Since this implant often fractured because of its material construction (Ledermann 1977), Ledermann developed the TPS® screw in collaboration with the Straumann Institute in Waldenburg. Three or four further implant variants have been developed from this original design. The first, the Ha-Ti® screw, was developed by the group of Ledermann and Mathys over the period from 1983 to 1985. The second, the NLS screw, was developed in 1986 (Ledermann 1986). The third was the Straumann screw developed in the 1990s by the ITI group. A cylindrical modification derived from the original root-shaped (conical) Ha-Ti® screw implant was reported in 1998, with one-piece implants exactly like the original Ledermann screw, and two-part, sub- and trans-gingival self-tapping screws under the new name: SPI® (Swiss Precision Implants). The cylindrical SPI® screws have the same micromechanical prefabricated superstructural elements tried and tested in the Ha-Ti concept over almost twenty years.
Immediate loading

Immediate loading means immediate functional commissioning of freshly inserted screw implants on the day of operation by means of blocking, for example using a bar, and simultaneous integration of the bar prosthesis (Ledermann 1977, 1978, 1983, 1986, 1996, 1997, and 2003). This immediate postoperative blocking provides functional splinting and eliminates the damaging rotational forces that would otherwise be exerted on transgingival screws as they are incorporated. This minimizes the risk of implant loss during the critical phase of osseointegration. Furthermore, a second operation for an osseointegrating implant is unnecessary, and the patient does not have to endure a worse fitting prosthesis than previously for several months. With the immediately integrating bar and the corresponding bar prosthesis, the implants are incorporated under functional conditions. This phenomenon has been confirmed several times by histological examination of functioning resection at post mortem (see below) (Ledermann, Kallenberger, Rahn and Steinemann 1985, Ledermann, Schenk and Buser 1998).
Figure 2: First immediate loading of TPS® screws 1977

Figure 2b: Radiograph on day of operation before integration of immediate bar 1977

Figure 2a: Immediate bar introduced over four transgingival TPS® screws 1977 (Ledermann screws)

Figure 2c and 2d: Radiographic follow-up 2002 and clinical condition 25 years later. After 10 years, bilateral attachments were soldered distal to the end of the bar to obtain better retention of the prosthesis. Because of the small space between the implants, only a small bar segment or matrix could be integrated, and thus retention was not optimal.

Paradigm shift

Concerning immediate bar prosthetic care of freshly inserted screw implants, Hodel, Y. (2002) has written:

“Based on earlier studies, it has been established that directly loaded interforaminal implants with a bar in the mandible give very good results in edentulous patients and eliminate the need for a four-month incorporation period before osseointegration is achieved. All patients were satisfied with their care, especially because the prosthesis was securely anchored immediately after the surgical procedure and an osseointegration period with a poorly fitting prosthesis was not required. Primary loading of interforaminal implants is now regarded as the therapy of choice for edentulous patients in our clinic.”

Schaerer, P. (2002), writes that the healing time of three to six months recommended by Branemark 30 years ago was determined empirically and must now be called into question as a result of modern implant research. Schliephake, H. (2001) maintains that the idea of immediate loading of implants is not new since: “As early as 1983, Ledermann reported a success rate of 91.2% in a series of 476 implants, in which four TPS® implants were blocked using a bar after interforaminal insertion and immediately loaded. Schliephake further maintained that, at almost the same time, Adell and Branemark from the Scandinavian school reported an almost identical success rate of 91.0% in 385 implants with loading only after complete incorporation.”

The similar success rates using diametrically opposed methods justifiably lead Schliephake to examine the backgrounds to the two different concepts. According to Schliephake, the starting point for the Scandinavian school of Branemark is that bone undergoes partial necrosis because of unavoidable trauma during preparation with resorption and later replacement by newly formed bone. Thus, anchoring under loading can only be achieved after healing and complete replacement of necrotic bone, and this requires a healing phase without loading. According to Schliephake,
the Scandinavian position contrasts with that of Ledermann, and he furthermore writes of the Swiss school:

"By contrast the Swiss school (Ledermann) had concluded by 1979 that functional loading can only aid bone regeneration, and thus immediate loading must increase ‘structural biocompatibility’ and with it anchoring in bone." Schliephake explains that this apparent contradiction is present in nature itself: “because of its structure, the organ system is able to transform mechanical stimuli into biological impulses.”

One can cite here the histological evidence of Ledermann et al. 1985 and Ledermann, Schenk and Buser 1998, which confirmed this phenomenon scientifically. In addition, Khoury and Happe (2001) confirmed:

“Immediate loading of endossial screw implants with primary blocking has been tested since the 1970s (by Ledermann) with good results in the mandible for stabilisation of covered prostheses carried by bars.”

Grunert and Norer (2001) also concluded:

“In order to shorten or spare patients the unpleasant interim period, Ledermann has for more than 20 years proposed the concept of simple treatment with a bar prosthesis within 24 hours after surgery using prefabricated DOLDER bars that block the implant allowing immediate loading. Immediate loading implants give high patient acceptance and satisfaction …”

Finally Vitzethum (2001) writes:

“Immediate loading is logical for certain surgical and prosthetic conditions. It is the “original Swiss model.” Philippe D. Ledermann introduced this concept of immediate loading more than 25 years ago, and the swings in opinion are typical of ideas that are ahead of their time.”

Transgingival implantation versus open implantation


Transgingival screw implantation is only indicated if the mandibular body is sufficiently broad in the vestibulo-lingual dimension. This minimally invasive surgical procedure requires great experience and is not recommended for those with less experience. In the transgingival procedure, the first step is to punch out holes in the intended implant sites using a punch. The circular mucosal plugs show the exact thickness of the mucosa. Next, the cortical bone is ground down using a round burr. Pilot holes are then drilled, and the bore stud is prepared using a spiral drill. Because a thick mucosal cushion sometimes simulates a wide mandibular configuration, pre-operative radiography is essential. If it is impossible to establish that the alveolar ridge is wide enough, transgingival screw insertion should be abandoned. It is often impossible during TG procedures to assess the state of the sublingual mandible (for instance, marked necrosis). As a consequence, lingual perforation may occur during vertical cavity preparation leading to a so-called “unexplained error”

Transgingival insertion has the huge advantage that it minimizes the area of damage to ectodermal integrity. Besides, no sutures and no special wound care are required. In addition, there is no swelling or bruising, and the patient has no pain. The purely technically procedures of implant bed preparation and insertion of the screw do not differ in principle from the open procedure (Ledermann, 1984 and 1986).

The open method and the prosthetic procedure have not changed since 1977, and have been published several times. For details see the literature (Ledermann 1977, 1978, 1986, 1988 and 1996; Babbush 1986; Kinner et al. 1989, Krekeler et al., 1991; Besimo 1992; Buser 1994).
**Figure 3:** Ridge views from radiography for TG or AK methods

![Radiography Image]

Left, broad alveolar bone in the vestibulo-lingual diameter = suitable for TG method. Right, peaked crest= initial situation for AK method

**Figure 4: Immediate restoration with open approach**

**Figure 4a:** Edentulous mandible: because of the narrow ridge, screws have been inserted using an open procedure

![Implant Insertion Image]

**Figure 4c:** Before suturing, the bar caps are sited for taking impressions of the implant head

![Bar Caps Fixed Image]

**Figure 4e:** The existing prosthesis is hollow ground frontally in preparation for taking the impression

![Prosthesis Hollow Ground Image]

**Figure 4g:** In the parallelometer, the prefabricated Dolder® bar elements (attachment profile) manufactured by Cendres & Metaux are fitted precisely between the prefabricated bar caps and soldered on.

![Parallelometer Image]

**Figure 4b:** The four correctly inserted SPI® screw implants in the interferaminal region after ridge levelling

![Implant Insertion Image]

**Figure 4d:** The bar caps are fixed with occlusal screws and ready for the bar pressure impression. The thick suture prevents the impression material from getting under the mucoperiosteal flaps.

![Bar Caps Fixed Image]

**Figure 4f:** The Kelly impression (zinc oxide – Eugenol paste) simultaneously takes impressions of the solder and inner lining

![Prosthesis Hollow Ground Image]

**Figure 4h:** On the afternoon of the operation, the immediate bar for immediate loading of the SPI® screws is integrated for functional loading

![Parallelometer Image]
Figure 4i and 4k:

The matrix ensures optimal prosthesis retention. The bar-attachment prosthesis is supported almost entirely by the implant. The four SPI® screw implants and their prosthetic loading provide immediate functionally stable blocking, bone turnover starts immediately post-operatively allowing targeted function, as masticatory forces are transformed into physiologically directed impulses for new bone formation. Immediately after the operation, the patient has perfectly fitting dentures.

Variations in immediate bar restoration

In principle, implant bar care simulates conventional bar prostheses. Thus, two-, three-, four- or six-implant bars can be integrated into the edentulous jaw. **In the mandible**, incorporation of four SPI® in the maxilla incorporation of 6 SPI® screw implants, with immediate functional loading with the bar prosthesis has been shown to be reliable and safe.

Figure 5: Immediate bars in the mandible and maxilla

Figure 5a and 5b: Two-implant bars in the mandible for a “social indication,” clinical situation and radiograph

Figure 5c and 5d: Three-implant bars as a “medium solution,” clinically and radiologically

Figure 5e and 5f: Four-implant bar in the mandible = classical Ledermann bar, clinically and radiologically

**In the maxilla** incorporation of six SPI® screw implants in regions 14 / 13 / 11 and 21 / 23 / 24 with immediate functional loading using a bar prosthesis has been shown to be reliable and safe.
Over the years, a six-implant bar has turned out to be the ideal solution in the maxilla, clinically and radiologically.

**Histology of immediate bar resections**

Functional osseointegration or ankylosis of immediately loaded screw implants was first studied histologically in human bar implants in 1985 after three and a half years, and then after twelve years in 1998 (Ledermann, Kallenberger, Rahn and Steinemann 1985, Ledermann, Schenk and Buser 1998). Comparing the histological findings from 1985 with those from 1998, it is clear that osseointegration (Branemark, 1977, 1986), ankylosis (Schroeder 1994), or bonding osteogenesis (Strunz 1985) not only remains after functional loading of many years’ duration, but that this physiochemical bone-implant bonding increases in intensity over the years. This phenomenon has been confirmed by the increasingly negative periotest values over the years on follow-up examination.

**Figure 6**: Implant bone and soft tissue sample after 12 years

**Figure 6a**: Osseointegration: The newly formed bone lies directly under the implant surface and increases with function, and can be explained by direct transmission of chewing pressure to the bone (absence of desmodont)

**Figure 6b**: Mucosal integration: A mucosal cuff has formed at the site of insertion of the implant screws, with clearly structured epithelial and subepithelial tissue with a complex structure
The prefabricated elements of the immediate bar

The bar cap and all exchangeable parts of the SPI® superstructures are manufactured to high precision using micromechanical industrial tools. This ensures a tight, consistent fit. Using these methods, the problems associated with poor fit, reported by Strub et al. (1984), are elegantly reduced to a technical minimum. According to Bodenschatz and Besimo (1993) and Besimo et al. (1994) the gap with the SPI® concept is two to four microns.

Figure 7: The prefabricated elements for immediate care using the SPI® concept

One- and two-part Ledermann screw from SPI®

<table>
<thead>
<tr>
<th>One-part</th>
<th>Two-part type</th>
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<tr>
<td>SPI® Direct (Ledermann screw)</td>
<td>SPI® Element</td>
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<tr>
<td>two-part implant</td>
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Occlusal screw
Bar cap
Bar support

Optimisation of the immediate bar

Four-implant bars allow optimal prosthesis retention with outstanding comfort. The presence of four implants allows optimal spreading of the load in and onto the bones. The gaps between implants are large enough to allow long bridging segments, with polymerisation of correspondingly long matrices, which have less risk of sheering and breaking. The curved arrangement of the implants along the anterior ridge is a prerequisite for integration of an attachment bar. If needed, it can be extended distally by up to five millimeters. The attachment bar allows optimal retention of the prosthesis and prevents rotational movement. In addition, the dental replacement is almost completely supported by the implant. The problem that is often encountered of too little stable matrix can be solved elegantly if, instead of the microbar, the macrobar is used. Retention is markedly better and the matrix never breaks.
Results

Using the Implant data base (IDB) of Bleymüller it was possible to assess and evaluate 5647 screw implants inserted over the period from 1975 to 2002, 423 implants with immediate bars in edentulous mandibles and 78 in maxilla with a total of 1968 screw implants.

CBS® from Sandhaus

Although the CBS® screw has optimal biocompatibility, its period of functionality is remarkably short. The reasons for this are the fragility of the material, aluminium oxide ceramic, and the complicated method of fixing (cementing). Overall, 31 CBS® implants were used during the period from 1975 to 1977. The oldest implant is 28 years. However, the success rate was only 39%.

TPS® (Ledermann screw)

The results with TPS® screws are more favourable. They were used from 1977 to 1986. Overall, 808 TPS® screws were inserted. 84 (10.4 %) required removal. The oldest surviving implant was 26 years. The success rate was 89.6%.

NLS® (New Ledermann screw)

The new Ledermann screw (NLS®) was used from 1987 to 1992, in a total of 363 implants. Six screws (1.7%) required removal. The oldest surviving implant is 16 years. The success rate is 98%.

Ha-Ti® (Step screw implant)

The two-part conical Ha-Ti® screw implant was first used in 1985 for replacement of single teeth (Ledermann et al. 1986). In 1986 the author initiated its use as an immediate bar implant. Since 1986, 363 Ha-Ti® bar implants have been inserted. Three have required removal. The oldest surviving implant is 16 years. The success rate is 98%.

SPI® (Screw implant by Ledermann)

In 2001, Ha-Ti® was taken over by the company Thommen Medical in Waldenburg. The name was changed to SPI® (Swiss Precision Implants) and at the same time a cylindrical, self-tapping one-part Ledermann screws and two-part screws were marketed. A total of 1139 SPI® screw implants have been used for all indications, not all immediate bars. 28 required removal. The oldest surviving implant is 5 years. The success rate is 98%.
Important points concerning implants surgery and prosthesis

In preparing the implant bed, intensive cooling with refrigerated Ringer solution is essential to avoid irreversible damage to the bone. Since the introduction of local and systemic antibiotics (since 1979), postoperative problems and complications have become uncommon. The freshly inserted screw implants must be absolutely stable from the start. Primary stability is a prerequisite for secondary stability = ankylosis. Immediate bars are clearly superior to all other pre-prosthetic surgical measures in edentulous jaws (Obewegeser 1959 and 1969). They are more efficient and less invasive, and yield more economical mechanical retention results.

Conclusion

Experience gained over almost thirty years of scientific and clinical implant work show that critical examination of one’s work and implants with consequent developments in implants, instruments and superstructures has made possible significant improvements in functional implantology. Endosseous implants with immediate bars function reliably if the basic lessons from dento-alveolar surgery, periodontology, hygiene, the prosthesis, and dental surgery are observed. From the reported long-term results, it is clear that the immediate bar method with self-tapping screw implants made of titanium is reliable, scientifically proven, and practicable. It represents the state of the art of science, research, and practice, and can no longer be regarded as a new-fangled therapy, as reported by Günther (1982) and Kellerhals (1983).

Glossary

<table>
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<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>CBS®</td>
<td>Crystalline Bone Screw from Sandhaus</td>
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<tr>
<td>TPS®</td>
<td>Titanium plasma coated screw implant by Ledermann: Institut Straumann, CH-Waldenburg</td>
</tr>
<tr>
<td>Ha-Ti®</td>
<td>(H)igh (A)nalogy (T)itanium (I)mplant by Ledermann and Mathys : Mathys AG CH-Bettlach</td>
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<tr>
<td>NLS®</td>
<td>New Ledermann screw, Friedrichsfeld, Germany</td>
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<tr>
<td>SPI®</td>
<td>(Swiss Precision Implant): Thommen Medical Switzerland, CH- 4437 Waldenburg and Thommen Medical Deutschland GmbH, am Rathaus 2, D-79576 Weil am Rhein). In 2001 HATI AG was taken over by Thommen Medical in CH-4437 Waldenburg and the implants were renamed SPI® implants (Swiss Precision Implant)</td>
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<tr>
<td>ITI®</td>
<td>Bonefit and SLA® are registered marks of Institut Straumann, Waldenburg</td>
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Discussion
The following points are crucial for success in the immediate bar method for freshly inserted screw implants in edentulous jaws:

- **Choice of a suitable type of implant:**
  The basic principles proved as reliable in oral Implantology.
  1. As implant form
     the self-cutting screw.
  2. As load mode
     the immediate loading
  3. As kind of fixation of the superstructure
     the screw-retained version.

  The SPI® implant, manufactured according to the Ha-Ti® construction principle has the best survival rates on Kaplan-Meier analysis, allowing many unpredictable superstructural reconstruction options. Later extension and/or other changes are simple and easy to carry out.

**Possible reconstructions with the SPI®System**

- **Four-implant bars in the mandible**
  (80.3% of all bars) give an optimal chance of success and guarantee significantly better retention for the prosthesis than three-implant bars (10.9 % of all bars) or two-implant bars (6.8%).

- **Two-implant bars**
  give significantly worse prosthesis retention than with three- or four-implant bars. The results are unsatisfactory (Ledermann 1986 and 1996, Beneke 1995). They also break more frequently (Tetsch, P and Tetsch, J. 1996).

- **Six-implant-bar in the maxilla**
  Have been shown to give the best results since the quantity and quality of alveolar bone are less favourable in the maxilla than in the mandible.

- **Immediate bars in the elderly**
  The largest proportion of patients for implant-immediate bar are in their 60s. However, good results can be anticipated even in those over 80 years – with four patients over 100 years of age. Although the subject of osteoporosis is often raised, it does not seem to be a great problem in this indication.

- **Immediate loading**
  Through immediate integration of the bar on the day of surgery and simultaneous functional loading of the implant through the bar prosthesis vastly reduce the risk of implant loss compared with unloaded incorporation. In addition, the patient is able to eat and speak after implantation – he or she does not need to put up with a poorly fitting prosthesis for months.

- **History, diagnosis and explanation**
  In modern ilmpplantology a precise history, medical clarification if necessary, and explanation during the planning phase are essential. The explanation to the patient should employ diagrams (Ledermann 1986 and 1996), or an easily understood and well-illustrated brochure, as recommended by Tetsch, P and Tetsch, B. (1992). The patient must also be told about the need for compliant implant care and follow-up. Even if the prognosis is excellent, the patient needs to know that there is some risk (Tetsch 1991). Despite the best efforts, success can and must never be guaranteed.
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Address for correspondence:
Dr. Philippe D. Ledermann,
Nydeggstalden 2, CH-3011 Bern
eMail: dr.p.ledermann@bgb.ch