Consensus for dental implantology:
Description of the ways to achieve osseointegration.

From the
Dental Implant Faculty
International Implant Foundation
DE-80802 Munich
Germany
e-mail: contact@implantfoundation.com

I. Terminology

In dental implantology the term "osseointegration" is used to describe a condition in which vital, sufficiently mineralized bone tissue is joined with implant surfaces in a force- and form-fitting way, such that a permanent transfer of forces from different directions becomes possible in or on the bones.According to traditional thinking, the achievement of osseointegration of dental implants represents a biological process in which bone tissue actively becomes closer to implant surfaces. Various biological routes that lead to this goal can be subsumed under the term „biological osseointegration". The successful application of immediately loaded implants in all regions of human bones suggests that this biological integration of implants cannot constitute the only way to achieve permanent implant integration.

II. State of development

In the field of orthopaedic surgery, the force-fit immediate loading of implants has been the most up-to-date technique since the introduction of screws and plate osteosynthesis (c. 1980). In the treatment of limb fractures, not only are the screws for the fracture plates used at the same time, but the fracture plates themselves are also used. The well-understood patient's interests and surgical practice are in harmony here. By contrast, in dental implantology - depending on the type of implant used - a delayed (two-stage) procedure is still practiced. The argument for sterile submerged healing to prevent infection can be applied to implant designs with a wide diameter at the implant neck along with a surface-enlarging structure. In the meantime, various implant systems are now available to implant specialists that either allow for immediate loading or have been especially developed for this treatment option. It has long been a matter of contention as to whether after reaching the so called „osseointegration" there is a final, ultra-thin layer of connective tissue between the implant and the bone, or whether bone matrix is really deposited directly on the implant. Evidence in the form of histological cuts has been submitted for both variants. Therefore, it is clear that there are at least two different ways to achieve "biological osseointegration".

Quite a few two-phase implants could also be used in immediate loading. In practice, however, the bone necessary for their use is lacking, which is why the use of these implants is then combined with bone augmentation measures. Hence, the possibility of an immediate loading is lost.

A great many systems to be found on the world market – and, regrettably, even some marketleading systems – are unsuitable for immediate loading due to the implant designs. As a rule of thumb, those systems of which the manufacturer claims that their special surface promotes an increase in bone growth, tend not to be designed or suitable for immediate loading, because such bone growth takes several weeks or months and furthermore creates open spaces (or at least cracks) in the vicinity of the implant. To date, there is no verifiable scientific evidence that certain features of the endosseous implant surface (etching, sandblasting) would favour the immediate loading of dental implants or even enable it.

By contrast, it is well known that surface-area enlargements contribute in the medium- and long-term to the development and/or maintenance of peri-implantitis.

Long-term clinical experience in orthopaedic surgery and especially traumatology has shown that bone implants macro-mechanically anchored in cortial bone may be subject to immediate loading under generally favourable circumstances. Here, a distinction is to be made between movement stability, primary stability and load stability. Basically, in traumatology and orthopaedic surgery, the early resumption of functionality is desirable because only sufficient functioning can protect against atrophy through disuse and the associated demineralization of the bone.

III. Ways to achieve the integration of dental implants

a. Biological integration in woven bones and dual healing

It is to be assumed that the known processes of bone fracture healing shall also be used in healing processes concerning dental implants. All known histological studies show that, following surgery, where there is (enough) space between the endosseous implant surface and the bone, woven bone is formed. This new bone formation starts from the vascular system, with the matrix being secreted by the osteoblasts and substrates in order to carry out this task. Numerous implant manufacturers attach so-called “bone bays” to their implants, which offer more space for the reformation of woven bone around the implant. As a result, there is an initial sheathing of the implant with woven bone. For smooth sheathing, the nature and topography of the surface play a decisive role, because it has proven advantageous for this step that coagulated blood adheres to a roughened implant surface.

Direct osteogenesis and distance osteogenesis have been postulated as two distinct cases of bone formation on a braided-bone basis. This hypothesis is based on histological observations in the early period after the bone implantation (< 4 weeks).

Unfortunately, the type of biological osseointegration which is described above in IVa is almost exclusively the subject of university studies and university dental research. In vain, and probably at the instigation of the marketing departments of market-leading manufacturers, an attempt was made to advance a proof that certain implant surfaces stimulate faster osseointegration according to IVa. However, in doing this, they overlooked the fundamental fact that woven bone can only provide stability if it has disproportionately large spaces for bleeding and the development of the woven bone (compared to substantially more stable bone). Such conditions exist, for example, in the healing of fractures of long bones in the extremities: the space is created between the periosteum and the lamellar bone surfaces (subperiosteal callus) or within the long bones (endostealer callus). The microscopically small gap areas that arise in the environment of smaller dental implants after insertion cannot be assumed to be an adequate volume of woven bone that is clinically usable for immediate loading or power transmission. As is well known, publications, especially regarding the so-called „SLA surface“, have not stood up to scientific investigation.

b. Biological integration into osteonal bone

By contrast, histological observations paint a different picture: instead of the woven bone, secondary osteons are to be found directly on the implant. Since all osteons basically have a thin outer non-mineralized limiting membrane, with an osseointegration achieved in this way, there is no direct contact between the mineralized bone matrix and the implant surface. It is assumed that the „bone-friendliness“ of the implant material and the implant surface for this kind of biological integration plays a far smaller role than it does for the integration of implants in woven bone as a result of the conversion of coagulated blood. The direction of osteonal remodelling is known to be influenced by endosteal stress and not by chemical signals that could come from specially constructed implant surfaces.

c. Gap Jumping & Slip Lines

Within the bone, trabeculae may also be formed without prior woven bone matrix. The integration of implant surfaces over distance without prior woven bone formation has been described in the field of dental implants and in the field of trauma implants on the basis of histological examinations. From this, it can be seen to be the case that the advance of the bone occurs directly through endosseous tissue that may serve as a lead compound to the bone.

The displacement of different bone levels via the „slip lines” is to be distinguished from this process. Such displacements along or within the osteons could contribute to early post-operative graft stabilization, especially in the lower jaw

IV. Implant types for achieving immediate osseointegration

d. Implants supported purely cortically

For a long time, implants supported purely cortically – so-called "basal implants" – have been known about and have been in use. These systems can be grouped into two sub-groups (see also: Konsensus on BOI, www.implantfoundation.org):

Lateral basal implants are supported by cortical bone areas, either across a wide surface or punctiform, depending on the spatial situation of the insertion. However, although they are used in immediate loading, due to the design, they cannot be used everywhere and be immediately osseointegrated. Nevertheless, increasing osseointegration of these implants occurs over time, via the procedure described in a.) and the one described in b.). Areas located centrally in the jaw bone lacking initial bone contact or polished implant areas also integrate by the process described by the under c.). Since the osteotomy slits bind with woven bone first, which is later osteonally remodelled, the term "dual" healing process, which has been suggested, is apt. The immediate osseointegration along all endosseous implant surfaces is not necessary. Immediate loading is indicated, provided that sufficiently large surface areas are in stable contact with cortical bone.

However, basal cortical screws, which, in terms of their functionality and structural elasticity, can also be referred to as basal implants, usually exhibit a broad, direct contact with the cortical bone immediately after insertion in the region of the basal screw. Since the remodelling tendency of these bone areas is not particularly pronounced, it can be assumed that an additional „biological integration" in the wake of the mechanical anchoring neither has to take place, nor will take place. The stability of the bone-implant composite of lateral implants is defined solely by the amount of cortex existing before surgery and its degree of mineralisation. Therefore, it is not necessary to provide such implants with any particular surfaces; it is sufficient to use polished surfaces or titanium. However, infection-preventative, physically acting additives on the surface can be helpful, such as is the case with the Osmoactive® surface. Coatings with biphosphonates or strontium have also been found to be effective when it comes to the reduction of implant-related, post-operative remodelling.

Cortically-supported implants should either be incorporated in high-grade mineralised bone area or in such a way that the so-called „2nd cortex" is reliably reached with the thread sections that are at opposite to the abutment. To ensure this, the surgeon will typically (fully) penetrate the cortical bone of the maxillary sinus, the nasal floor, the distal maxilla, the pterygoid process and the lingual cortical bone of the lower jaw in various directions.

The macro-anchoring procedure described has been in place in orthopaedic surgery for a long time, and is particularly widely used in traumatology. It can also be used in dental implantology and can be referred to as „immediate osseointegration".

e. Corticalisation of cancellous bone areas

If dental implants (especially in the upper jaw) are introduced in accordance with Brånemark's concept – which used to be prevalent – in predominantly cancellous bone areas (D3, D4 bones), then there only exists a limited opportunity to remove the existing bone for the insertion of the implant. Furthermore, the bone is compressed laterally. This compression may increase the degree of bone mineralisation in the vicinity of the implant, whereby significant primary stability can be achieved even in bone that was already of a low quality to start with. In addition, a targeted and localized damage to the bone structure occurs in the compression zone. The damaged bone remodels at a lower rate than undamaged bone. Fortunately, the implant stability will thus be increased even in the medium- to long-term, which can make immediate loading protocols possible and extend the short time span up until the prosthetic restoration.

For this procedure, only implants with tapered core design (e.g. KOS, Hexacone, Nobelactive) can be considered, since it is practically impossible to condense bone along the vertical axis of the implant in the case of cylindrical implants (e.g. Straumann Synokata).

Due to the bone condensation, a woven bone formation according to IV a. can no longer occur in the immediate vicinity of compression screw implants, because the space for it is lacking. Therefore, the special surface qualities of the implants play no role, at least in terms of the healing process. However, surface enlargements (e.g. via sand blasting) increase the necessary reverse-torque forces and thereby the stability.

Improving the quality of the bone bed by compression can lead to excellent results being achieved in immediate loading even with reduced bone availability or quality. Today, the indications for so-called „bone augmentation" are therefore even more limited, meaning that osseous structures can now be limited to aesthetic corrections. The risks and side effects, as well as the collateral damage, are known to be considerable.

This approach works regardless of whether the implants are of one- or two-piece construction. However, for fundamental reasons (increased costs, practitioner circumstances, or the possibility of getting away from multipart screwed constructions) it no longer makes sense to continue using two- or even multi-part implants.

f. Combined implants

Recently, implants that have both compression areas and self-cutting threaded areas for anchoring in the 2nd cortex have appeared on the market.

V. Summary

Today, in dental implantology, both the formerly common integration concepts with unloaded healing times (according to Brånemark) and modern concepts are used in the immediate loading protocol.

We therefore distinguish the „biological osseointegration“
- in woven bone
- in osteonal bone
- and gap jumping,

from the
- direct integration into cortical bone (under compression) and the
- direct integration in compressed cancellous bone
- a combination of the two before mentioned direct integration techniques.

Essentially, the concepts outlined in IV d., IV e and IV f. lead to the possibility of secure immediate loading in dental implantology. However, concepts that include a „biological integration“ and requiring woven bone formation for stabiity reasosns are not even theoretically suitable for immediate loading protocols.

Given the very good opportunities that we have with modern immediate loading implants, any bone augmentation should be done away with, with the exception of the occasional aesthetic justification. With the exception of single-tooth implants, basal implants or compression screws can generally be used to treat all standard situations and in most immediate loading protocols.

Treatment with two-piece implants using delayed loading protocols (specifically involving bone augmentation) is from today‘s perspective both an unnecessary complication, and an expensive detour in the implant treatment of edentulism.