Part 1- The history and concept of implant

Chapter 1 Dental implants

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I. Definition of implants

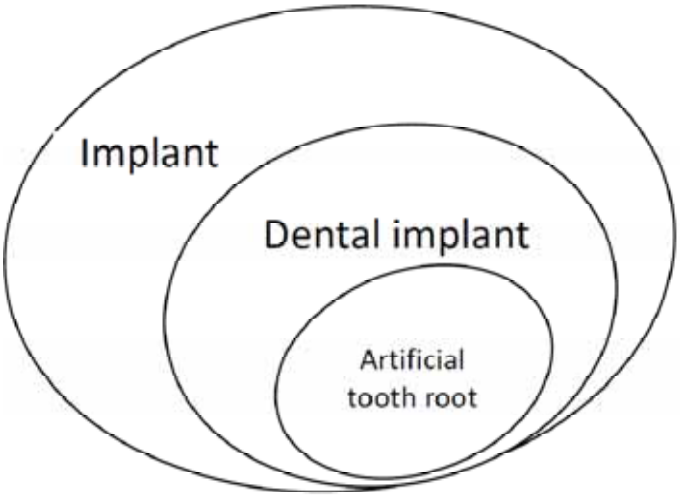
The social recognition of implants in dentistry has shown a dramatic increase in recent years and in Japan the term “implant” has come to represent dental implant. However, the definition of a dental implant: “artificial material that is inserted into the jawbone or the periosteum by an invasive method, and one that can be used as a substitute for teeth”, is vague, and has not been strictly defined. An appropriate name for a dental implant that would be most suited to current practice would be the term, “artificial root”.

This definition may cause slight confusion. In searching the term “implant” in the PubMed database, 46,575 medical papers were extracted at the time of writing (5.2.2008). In comparison, 9,768 papers were extracted with the keyword “dental implant”, a mere 20 percent of the former search result, thus suggesting that the term “implant” is not uncommon in the field of medicine. That is to say, it is impossible to identify “an implant as a dental implant”; it is therefore necessary to write the words “dental implant” to achieve more specificity.

The term “implant” itself remains ambiguous. According to the “Glossary of Oral and Maxillofacial Implants”, which was compiled by W. R. Laney who served for a long time as the Editor in Chief of the International Journal of Oral and Maxillofacial Implants (JOMI), an implant is defined as “an artificial material or tissue that shows biocompatibility upon its surgical implantation”. This is inclusive of implants that are removed afterwards for diagnostic or experimental purposes.

This definition has been authorized by four academic groups: the Academy of Osseointegration, the American Academy of Periodontology, the American College of Prosthodontists, and the European Association for Osseointegration. The use of this definition, however, would indicate that dental implants include composite resins and crowns, and cover allografts in the terminology.

If the term implant is to be re-defined in the context of current practice, it should be defined as follows: “an artificial material that is inserted into the jawbone as a replacement for a tooth”. As we, having come this far, have no intention of causing confusion, the term “dental implant” will also cover the following: implants for correction, membranes used for guided tissue/bone regeneration (GT/BR), and materials for osseous implants including autologous bone. Further, a more specific definition should be given for materials such as artificial roots, for example, “artificial material that is inserted into or onto the jawbone for the purpose of replacing teeth”.



II. History of the implant

As shown in Table 1-1-1, the history of the dental implant goes back to 3000 B.C., to the period when the ancient Egyptian civilization prospered. In this book, we will cover the history of dental implants from the time of Allen's report[1)], which in 1687 was the first to mention dental replantation and transplantation, and from the 1800s, the period where the practice of modern surgery started, along with the concepts of sterilization and disinfection. This was the time when medical information started to be written down and be provided in paper form.

Time	Reporter	Reported year
3000BC	Bremner ADK	1954
2500BC	Coleman AI	1970
550BC	Atilla G	1993
600AD	Asbell MB	1988
800AD	Ring ME	1995
1050-1122 AD	Coleman AI	1970

Table 1-1-1[2)-6)]
Reports of Dental Implants until the 17th Century

During the period from the 1500s to the beginning of the 1800s, teeth were bought off from the resurrectionists which were collected from the poor or the corpses for purposes of allotransplantation[5)]. This method, which was most common in Europe, has since disappeared for various reasons, particularly due to the common onset of secondary infections such as syphilis and tuberculosis[7)].

It is most probable that the first person to publish a description of the technique of modern dental implants was a French dentist, Maggiolo J. According to M.E. Ring, Maggiolo describes a method to implant 18-karat gold alloy, with three branches into the jawbone, and to install a porcelain crown as a superstructure in his book: "Le Manuel de l'Art du Dentiste" (1809) [6)]. By 1886, the process of

intraoperative sterilization had undergone vast improvements, in which time, Harris had constructed a socket in the jawbone to insert a column made of porcelain. Interestingly, this porcelain was coated with a rough layer of lead in order to increase the supporting strength. A porcelain crown was placed as the superstructure, and this is the approach that is thought to have continued for 27 years[6].

In a similar manner, in the latter half of the 1800s, Berry constructed a root-form implant that was lead-free. Following this trend, Pajime used silver, and Bonwil, gold and iridium as the material, each of which were implanted for single tooth replacement or for support of a complete denture[7].

Entering the 20th century, Scholl made a root-form, porcelain implant in 1905 that consisted of corrugated structure. He also proposed a design in which a wire was initially incorporated within the superstructure for forming a connection with the remainder of the original tooth[7].

Most of the surgical methods for dental implants in the past had involved immediate implantation. However, surgical tools such as the drilling systems used in present practice were developed and improved by Greenfield, who also introduced trephine bur and dental implants with a hollow cylindrical design. He was also the first to report the failure of implant treatment due to infection, and thus his contributions to the history of dental implants are immeasurable[6].

In 1937, Vitallium®, a cobalt-chromium-molybdenum alloy was developed which was used on patients by Stock at Harvard University. Some of these cases were followed-up for 15 years until Stock's death[7]. Meanwhile, in 1940, Dahl was the first to attempt subperiosteal implant, but this approach did not become common before being employed by Gershkoff and Goldberg in 1948.

In 1951, the Academy of Implant Dentures was established, which is presently known as the American Academy of Implant Dentistry[9].

Reflecting back on the dental history in Japan around this time, the late Dr. Toshio Yamane set up the Yamaguchi Plastic Dental Society in 1956, which later became the driving force for Artificial root research in Japan. Dr. Yamane established an independent institute to experiment on animals, which produced many experts in the field of artificial roots. The institute is currently known as the Japan Institute for Advanced Dentistry[10].

The oldest academic report in Japan is a collection of consecutive reports by Dr. Toshitaka Kaketa constituting a series of reports that were published in the academic journal of the Japan Prosthodontic Society. In retrospect, it is no exaggeration to say that his achievements in the 1950s–1960s were monumental, particularly in the time when the opportunity to report the use of artificial roots was limited and this kind of practice were not kindly perceived[11)-19)].

The Japanese Society of Dental Implants was established in 1972, however, due to a series of difficulties, it was not until 1978 for the academic journal to see the light of day. Later, it merged with the Japan Society of Dental Implant Research becoming the present Japanese Society of Oral Implantology (JSOI) [20)].

Meanwhile in the area of basic research, Haruyuki Kawahara, one of the authors of this text, had discovered that the cell proliferation was unaffected by the presence of titanium or zirconia and tissue proliferation was found to be more effective on the surface of these metals than on the glass plate. At the time, however, the extent and the nature of biocompatibility of each of these metal materials had not yet been defined. The topic of biological characteristics of dental materials as a whole became a theme worth investigating. The results of such researches were summarized and published in the International Dental

Journal in 1968. This in turn triggered extensive researches into the biological properties of dental materials as a whole, and the results of these studies have appeared temporarily[21].

The story that the discovery by Brånemark in Europe 1950 that titanium can be integrated with bone, led to the concept of osseointegration, advocated in 1969[22] that is still applicable in current practice, is infamous. This has come to be known as Brånemark's theory and the concept of osseointegration flourished rapidly in the 1980s, which brought about a defining moment in the clinical field of implants. In Sweden at the time, the concept of dental implants was perceived with skepticism; therefore the term "fixture" was used instead to soften criticism.

Around the same period, in the United States, Linkow was developing the first screw-type implant called Ventplant, which was completed in 1963. This implant is currently referred to as self-tapping implant, which is covered with screw threads with an open-cage design. Cobalt-chromium alloy was used as the metallic material, but is said to have been replaced by titanium due to the results of Brånemark's research[22].

During the period of 1960s to the 1970s, surgical methods of bone regeneration, like those used today, had not yet become widespread, as the use of screw-type implants was avoided in narrow bone structures such as the jawbone, and the blade implant was considered "mainstream". Therefore, the Ventplant disappeared before it saw the light of day. Although this trend was also seen in Japan, Kawahara and Kyocera Co. Ltd. succeeded in the formation of monocrystalline alumina in 1975. Bioceram, which is the product name, became the first implant made in Japan for both domestic and overseas use. It has been said that the Bioceram was implanted in over 60,000 patients and was the most pervasive and well-researched implant among the dental implants manufactured in Japan.

In 1978, the Harvard Consensus Conference was held to establish consensus on the use of implants at Harvard University, and the standard for a successful implant was settled on whether the implant remained embedded and functional for five years. This standard may seem extremely short, but it illustrates what the expectations of implant treatments were at the time.

In the 1980s, Professor Zarb of the University of Toronto played a central role in holding the Toronto Conference on Osseointegration in Clinical Dentistry, where Brånemark presented the results of his research over 30 years and his clinical practice for nearly 20 years. With this Conference as a turning point, the Brånemark Regimen spread over North America. The typical Brånemark regimen during this period consisted of implanting four to six fixtures into the mental foramen of the lower jaw, with the subsequent placement of bilateral cantilever as the standard prosthesis. Brånemark also insisted that, after implantation, the fixture should be left for four to six months and be isolated from any kind of external force. This was when the surgical two-stage technique became widespread throughout the world, starting in North America, followed by the spread of the submergible design. Many clones of this design were produced and are still in use today.

Towards the late 1980s, the revolutionary movement of the Brånemark regimen swept over Japan in the same way, and a surge in implant research took place. This movement was a different kind seen with Linkow's Blade-type or the Bioceram that had its struggles, and has continued its uses to this day.

III. Types and characteristics of the implant

Implants can be classified into several types, such as subperiosteal, endosseous, and transosteal implant,

but, in this book, we will avoid mentioning implants other than endosseous implants, taking into consideration the types of implant that are currently used in clinical practice. Moreover, the endosseous implant can be classified roughly into blade-type and root-form according to its shape, but, in this book, we will only mention the root-form implant for the same reason as before, and classify these as shown in Table 1-1-2. The root-form implant can largely be divided into one-stage type and two-stage type, in accordance with the operative methods used. It is possible to use the two-stage implant as a one-stage implant and such usage has been increasing in recent years.

	Type	Typical products	Similar products which are on the market at present
One stage implant	One Piece Type	 AQB implant	NobelDirect Zimmer One-Piece Lifecore Prima-Solo Thomenmedical SPI Direct
	One-Stage Type	 Straumann Standard Implant	Platon Type I Lifecore Stage-1 Zimmer SwissPlus Thomenmedical SPI ONETIME
Two stage implant (One stage implant)	Two-Stage Type	 NobelBiocare Replace Tapered	

Table 1-1-2 Classification of the Root-Form Implants

A. One-Piece Type

The most primitive design is the one-piece type, and the AQB Implant that was developed in Japan is a typical example. At the time, the design of the AQB Implant was deemed retrograde as it was placed on the market in the golden age of the two-stage type of implant. However, even large enterprises such as Nobel Biocare and Zimmer Inc. have adopted this style. The major advantage of this type of implant is the absence of a microgap in between the abutments. In addition, it does not require any prosthetic procedures for implant placement, so there are no problems commonly associated with prosthetics. This type of implant seems to be the simplest and the easiest to use among the three types, however, it may be difficult to prepare the prosthesis when the major axis of the implant and the tooth axis of the prosthetic tooth differ significantly. This type of implant is unsuitable for cases where initial fixation is not adequate. Here, a large area of the implant is exposed in the mouth at the time of implantation, and thus is easily affected by external forces.

B. One-Stage Type

The Straumann Standard Implant is the most prominent one-stage type and is widely known by its old name, the “ITI Implant”. In addition to its advantage of requiring surgery only once, as the implant is communicated with the oral cavity from the time of implant placement, it is more resistant to the external forces than the one-piece type because the area exposed in the mouth is small, and it micromotion can be minimized. The positioning of the crown can be adjusted to some extent at the abutment level if the major axis of the implant and the tooth axis are not fitted correctly, as the crown is structurally separate but problems such as those listed in Fig. 1-1-1 can occur in the portions related to the abutments.

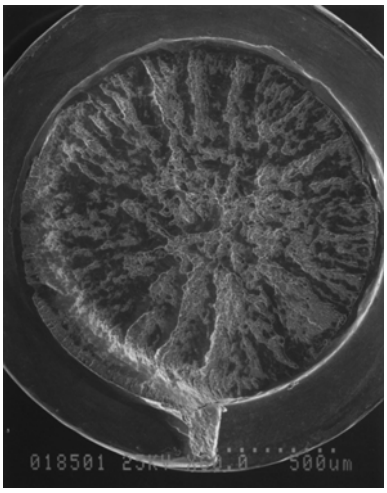


Fig. 1-1-1 Example of a rupture that occurred in the Octa® abutment of a Straumann Standard Implant

C. Two-Stage Type

This type is the most commonly produced of the two types, and in many cases, its design is adopted from the standard Brånemark regimen that act to minimizes micromotion by closing the wound after implanting the fixture. It is thus often used in cases where micromotion must be avoided in cases of poor initial fixation or in cases where bone is grafted to the periphery of the fixture. In principle, uncovering surgery that exposes the implanted fixture takes place after a period of several months, to allow subsequent placement of the transmucosal abutment that penetrates through the mucous membrane. There are more variations to the abutments than with the one-stage type, therefore it is possible to adjust the location of the crown more freely at the abutment level, but a considerable number of problems have been reported with the use of this type of implants (Fig.1-1-2).

Fig. 1-1-2
Contamination around the screw that resulted from the loosening of the abutment screw

Many companies have adopted the two-stage design, however, there has also been recent development of a method known as “immediate loading,” where the transmucosal abutment is attached in a similar manner to the one-stage type, at the time of insertion of the fixture.

IV. Style of the interface between the implant and bone

Extensive research into the interface between the implant and bone in terms of surface chemistry and morphology is continued to this day. Implants with various surface treatments have developed in response to the results of research. This book reports the observed surface chemical characteristics6 of the interface between titanium and the bone, in consideration to its morphological aspects.

A. Interaction between titanium and calcium phosphate compounds

It has been shown that phosphorus and calcium diffuse into the oxidative layer on the surface of titanium, by immersing it in “pseudo-body fluid” that includes calcium and phosphate ions. The elemental ratio of phosphorus and calcium in this oxidized layer approaches that of hydroxyapatite, 1.67, as the duration of immersion increases. This property was discovered by Dr. Takao Hanawa (Professor of Tokyo Medical and Dental University), who is one of the contributors to this text, and discovered that the calcium phosphate compound present on the titanium surface is hydroxyapatite, using Ultra-sensitive Fourier-Transform Infrared (FT-IR) Spectroscopy [23].

Previously, titanium was believed to be inactive in organisms as it was covered by an oxide layer that was stable in the atmosphere. However, it was found here that titanium is microscopically an active material, and that this phenomenon (which can be observed in pseudo-body fluid) is also seen on the surface of titanium removed from the living body. This was a monumental finding that unraveled the characteristics of the interface between titanium and bone at the atomic level, and that unmasked the nature of osseointegration, a biomaterial research result that Japan can be proud of. This finding also fueled the development of implants with a variety of improved titanium surfaces. As classic examples of formation of the oxidized layer, methods of immersing titanium in a solution that already contains calcium ion[24], or infusing calcium ions[25] are used. Both methods have been shown to accelerate the production of calcium phosphate effectively in pseudo-body fluids, and this phenomenon has also been confirmed to occur in animal experiments.

Other methods including alkaline treatments that immerse titanium in sodium hydroxide solution with the application of heat[26], or hydrogen peroxide treatment[27] have also been reported as methods for surface reformation that accelerate the production of calcium phosphate. With regards to the alkaline treatment, there have been many reported examples in the field of orthopedics, and bone induction has also been observed in muscle[28].

B. Interaction between Titanium and Biopolymers

In an electrolytic solution, it takes several weeks for calcium and titanium to grow into HA on the surface of titanium, but in an organism, hematogenous biopolymers such as fibrinogen and fibronectin rapidly adsorb and orientate on the titanium surface, and subsequently mediate the biological reaction (Fig. 1-1-3).

Fibrinogen is converted into fibrin which polymerizes to form a biological mesh. The subsequent

biological processes of wound healing are regulated by cell growth factors such as PDGF released by the platelets that were trapped by the fibrin mesh. As a result of this release, the proteins involved in ossification, such as osteocalcin, osteopontin, and osteonectin have been shown to be up-regulated[30].

Recent research has used osterix, a transcription regulation factor involved in the differentiation of the osteoblast, as a marker. It was found by Masaki et al. and Guo et al. that a hydrofluoric acid-treated implant shows a higher expression of osterix than those with SLA or SLActive treated surfaces [31),32].

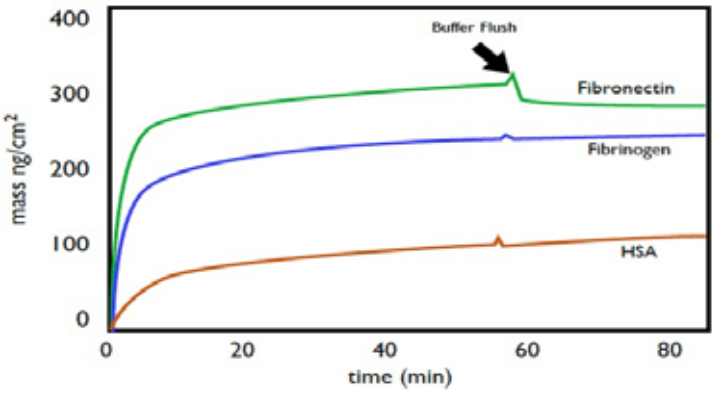


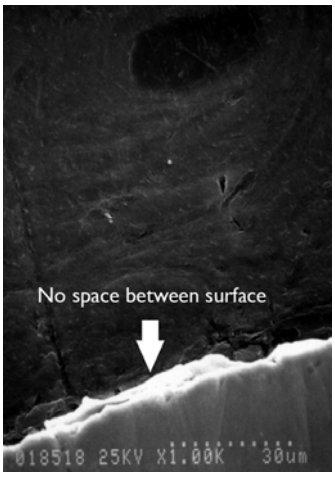
Fig. 1-1-3

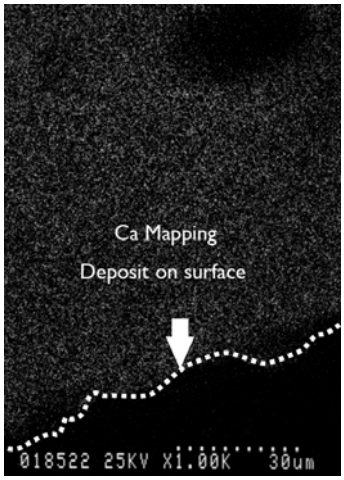
Quantitative adsorption kinetics measured for the proteins human serum albumin (HSA), fibrinogen, and fibronection on Tio_2 covered optical wave guide tips, using optical waveguide lightmode spectroscopy (OWLS). Protein concentration: 160 μg/ml. Flow rate: 1ml/h [29)]

C. The Dynamic Interface between Titanium and Bone

Based on the analysis of titanium and calcium phosphate with respect to the inorganic surface chemistry or using biological markers as an indicator, titanium and bone can be found to be interacting and be integrated with one another. However, the results from animal experiments do not always reflect these inorganic research results. Fig. 1-1-4 shows an electron micrograph of the results of application of a load after the initial implantation in a monkey[33)]. Fig. 1-1-4-a shows that no space between the fixture and the bone can be seen even with 1000 × magnification. Fig. 1-1-4-b shows that distribution of calcium can be observed along the surface of the fixture. However, in Fig. 1-1-4-c, it can be observed that the distribution of phosphorus is not concurrent with that of calcium and there is a phosphorous-deficient layer of roughly 10 μm.

Morphologically, these findings seem to suggest that, although the bone appears to be interacting with the fixture, in actual fact, it is not the bone, but special tissues lacking phosphorus that are interacting with the fixtures instead. That is to say, the term osseointegration only refers to a morphological observation, and even the implants that have not shown clinical mobility can be supported by specific tissue that is biochemically distinct from the bone. Unfortunately, whether this observation is continuous throughout the osseointegration process or whether it is limited to a specific period is not yet clear, but it can at least act as evidence that the bone and implant form a dynamic interface [34)].



a


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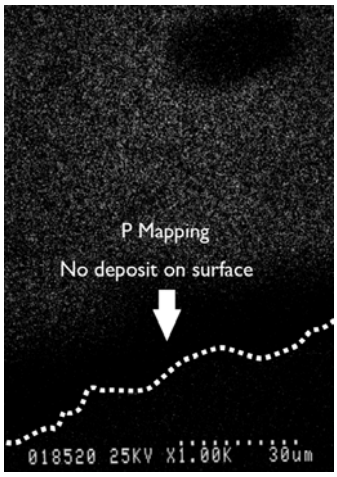

c

Fig.1-1-4-a,b,c

Atomic spectroscopy of the structures surrounding the fixture buried in monkey [33]. The image, taken with electron microscope, featuring the interface between the surfaces of titanium and the bone (Fig. 1-1-4-a). A localized image featuring calcium atom, under the same magnification (Fig. 1-1-4-b). A localized image of the phosphate atom under the same magnification (Fig. 1-1-4-c).

D. Interface between Hydroxyapatite and Bone

In response to the clinical demands, the means in which to accelerate the incorporation of calcium and phosphate at the interface between the bone and the implant had became the subject of research. One of the most typical examples is the method of HA coating on the surface of the titanium metal. Once the hydroxyapatite (HA) and bone interact, integration at a crystalline level is not an impossible task, as has been reported by Kato [35].

HA does not show any toxicity or tendency to induce local or systemic inflammation. Regardless of its shape, whether it is in the form of a block or granules, it has been found not to give rise to inflammatory or foreign-body reactions.

Furthermore, fibrous encapsulation does not appear; in fact, it is known that direct interaction with the bone occurs instead. Both HA blocks and granules gave satisfactory outcome in experiments using dogs, rabbits, rats, and primates in the fields of orthopedics and dentistry. There were no local or systemic side effects reported. With these findings, HA was considered an ideal material for implants. Nevertheless, results of clinical trials of HA implants were dismal, as it fractured or fell out within a short period of time. A swift change was incorporated with the construction of two-stage implants, but no improvements in prognosis could be achieved, and its use rapidly declined. However, the researchers did not relinquish; with clinically proven adhesiveness of HA to bone[36], the idea was developed to cover the titanium with HA in order to reinforce mechanical strength. After the report of Duchyne's group was published, technology to coat titanium or its alloy flourished[37], however, the method used to spray on HA at high temperatures, known as the plasma spray method, resulted in breakdown of HA with conversion into amorphous calcium phosphate (ACP). This resulted in liquefaction of the HA[38].

In addition, from the analysis of sintered or coated HA, HA is known to lose its hydroxyl group in the process of sintering or plasma spraying.

Therefore, the emergence of a "real" HA coating had been long-awaited[39]. In order to avoid the loss of the hydroxyl group, ADVANCE CO., Ltd. and a research group from the Institute for Medical and Dental

Engineering, Tokyo Medical and Dental University, published a method of spraying calcium phosphate (β-TCP) onto the titanium surface with the plasma spray method, as the raw material, followed by a hydrothermal treatment to coat highly crystalline HA onto the titanium surface [40]. Clinical trials of this HA-coated implant began at the Mitsui Memorial Hospital in 1988 [41] and, owing to this technique, properties such as its excellent biocompatibility and osteoconduction of HA were able to be revived. As shown in Fig. 1-1-5, the bone tissues connect with HA over the complete surface area showing a higher contact rate than any other titanium implant materials. Furthermore, its osteoconduction has been observed to be much faster than that of the titanium surface, and the contact area is much larger than SLA as shown in the SLA Surface Study by Buser *et al.*, which has often been cited for this type of research [42].

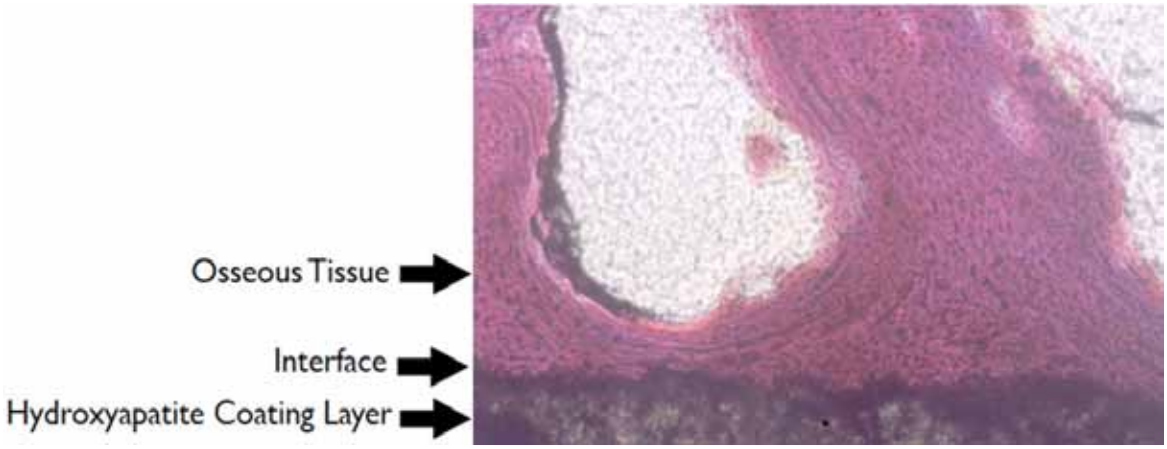

Fig. 1-1-5
Image of the bone tissue, which is strongly interacting with the HA coating layer.

V. Current situation and future trends for implants

A. Varieties of Implant and their Prognoses

A significant number of manufacturing companies produce significant variety of implants. According to a systematic review that evaluated clinical results of various types of implants, some research shows that the marginal bone loss associated with the cylindrical IMZ Implant is greater than that of the Brånemark System or the Straumann ITI. Concerning implants with smooth surfaces (machined surface), the risk of peri-implantitis is 22% lower than implants with rough surfaces. There have not yet been any specific implants with which its excellence proven over a long duration of time, or confirm that the failure to concentrates in a given type of implant.

This review was based on the results of a few randomized clinical trials, the number of people who took part in these studies was limited, and the assessment period were short, therefore, the results carry the risk of being biased. In order to draw accurate conclusions, a set of randomized clinical trials performed for a longer period are thus necessary, conducted in a sufficient number of patients to gain significance[43].

Surveying these articles that describe implant prognosis, it becomes clear that most of the authors of these papers are from university hospitals or from well-equipped institutions, where the pre-operative examination and diagnosis can be presumed to be conducted under the supervision of experienced surgeons. Therefore, it is not rational to directly apply the results of these studies to those of general

practitioners, and equal success in treatment should not be expected.

B. Surgical Simulation and Surgical Navigation

The foundation that supports surgical simulation and surgical navigation comprises computed tomography (CT) and computer-aided design/computer-aided manufacturing systems (CAD/CAM systems). The CT scan has a long history, but CT only assumed a prominent position with the publication of the DICOM standard in 1993 [44], and with improvements in the speed of data transmission over the Internet and the processing capacity of personal computers that occurred in the late 1990s. Handling of data for three-dimensional reconstruction became possible with personal computers, which in turn enormously improved both the precision of the preoperative medical examination and diagnosis.

Alongside the expansion of capacity of the personal computer that occurred at an exhilarating speed, many companies developed CAD/CAM systems. This in turn allowed not only medical examination and diagnosis but also preoperative preparation of a surgical stent capable of controlling the drilling direction most suitable for the bone surface, the remaining teeth, and the basal surface, even avoiding critical parts in the bone. Furthermore, we have entered a period that permits the construction of prosthetic superstructures before surgery, and some companies have already announced their implementation of these systems.

Fig.1-1-6 shows a conceptual scheme that combines on computer the scanned images of the basal surface and the remaining teeth as three-dimensional information, and information about the bone structure obtained from the CT scan. By re-constructing and combining these two sets of 3D information on the computer, a surgical index can be created that defines the direction of drilling in compliance with the remaining teeth and basal surface, and avoids more vulnerable parts of the bone, such as the lower alveolar canal.

Fig. 1-1-7-a is a picture of a plaster cast and Fig.1-1-7-b is an imaging index that complies with the tooth plane and basal surface by scanning the plaster cast. To prepare a surgical index (Fig. 1-1-7-c) compatible with the mucosal membrane and plane of the remaining teeth, the imaging index is used to check the intraosseous information gained from CT scan against the basal surface and tooth plane by making use of the relief surface on the front side of the imaging index.

The use of a surgical index that was constructed by combining details of preoperative soft tissue morphology and the bone tissue with CAD/CAM on computer, improves very significantly the safety of the "flapless fixture" surgical procedure, which in the past relied on intuition and prior experience[45]. This is a method whereby the implant is installed without detachment of the mucoperiosteal flap.

Fig. 1-1-8 is an overlapped image of the preoperative and postoperative CT scans.

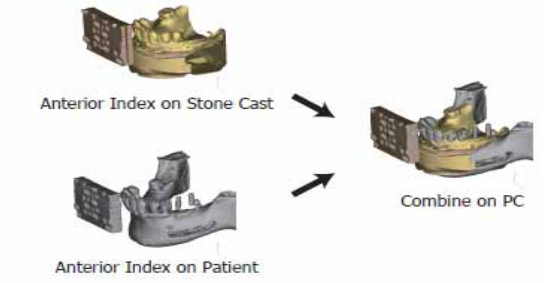

Fig.1-1-6

By compounding the 3D structure of the jawbone gained from scan of the plaster cast, and the 3D CT data on the computer, a surgical navigation can be created that corresponds well with the mucus plane and the dental plane to facilitate the regions of high risk.

Fig.1-1-7-a The plaster cast

Fig.1-1-7-b
The index for photography

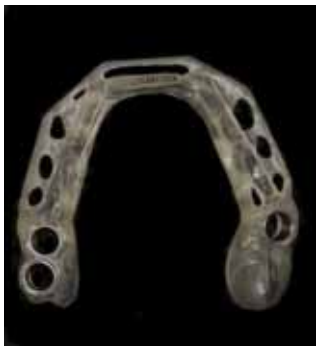

Fig.1-1-7-c
The surgical index

Fig. 1-1-7-a, b, c
The index for photography (Fig. 1-1-7-b) that was produced to fit the plaster cast (Fig.1-1-7-a), and the surgical index that suits the completed base. It is possible to control the orientation of the drilling by applying the surgical index on the surface of the mucosa and the remaining teeth for the preparation for the implantation in its flapless form.

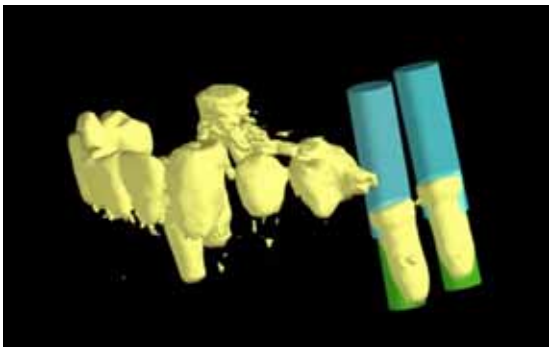

Fig.1-1-8
The superposition of the preoperative and the postoperative CT scan images. The cylinder structures shown in blue indicate the simulation of the preoperative simulation.

C. Immediate placement and immediate loading

In reflecting on current implant treatment in terms of material technology, the major advances in this field were recognition of the clinical significance of the HA coating, and the various reforms of the titanium surfaces. The most substantial among these was that the Standard Brånemark Regimen became an entrenched standard in the field of dental implants.

It gradually became clear that osseointegration would occur regardless of the use of two-stage surgery, or whether load was exerted immediately on the implant. This led to the concept of immediate loading. This is the clinical technique that was followed by practitioners such as Linkow[46], Cherchève[47] and Ledermann[48] for a long time, however, its presence as a clinical technique has become more relevant with advances in the materials used on the implant surface, and now that quality control has been instituted.

The number of reports related to immediate loading has increased substantially since 2000; these have demonstrated the anticipated value of the technique. From a critical point of view, the two-stage method that was advocated by Brånemark involved a detour, however, it is still of clinical significance in the history of dental implants as it provided us with a precise surgical method.

In addition, the method known as immediate placement became a popular technique. This method is also

one that opposes the idea proposed by Brånemark, but it is clear that, reflecting on past history, the original implant was installed immediately into the hole left by the removed tooth.

With awareness of infection, and the implementation of antibiotics, immediate placement became possible in an environment that is as clean as possible. The implementation of both immediate placement and immediate loading methods has been proven to be ideal for clients (patients), and systems now exist that employ this concept. Well-represented examples are Novum™ and All-On-Four™ which have been proposed by NobelBiocare. The former has already disappeared from the product lineup on the website of NobelBiocare, with only a few reports. According to De Smet, Novum™ and other implants that are designed to be inserted in distal positions carry a great risk if loaded immediately [49]. On the other hand, the use of All-On-Four™ in Japan has become more prevalent in 2007, and there have not been any major problems reported thus far. Progress has been smooth, however, the period of observation in several of the clinical trials facilities was not very long and careful surveillance therefore still needs to be maintained [50, 51].

VI. What is expected of the AQB implant?

At the first academic clinical presentation of the 1998 IAI Conference, two novel properties of the AQB implant were reported and demonstrated these with clinical examples. First, early loading of implants, where the secondary surgery can be conducted two weeks after the initial implant installation, and second, the fact that the movement of the fixture is not an irreversible phenomenon and recovery from this was shown with a clinical example[52]. These presentation were given in the midst of dental dogma of the Standard Brånemark regimen, however, the present practice of dental implants such as immediate installation of implants following tooth extraction, immediate loading, and immediate restoration, proves that the actual clinical results are much stronger than theoretical arguments.

There is a great number of clones and derivatives of the two-stage and one-stage types, but the model for the twenty-first century clones and derivatives of the single-stage type can be said to be those of AQB implant (Fig. 1-1-9).

More than a decade has passed since the AQB implant was introduced, during which time there have been significant advances in both the methods of assessment and surgery. From now on, what is expected of the AQB implant is simplification of the navigation systems that have been implemented for use of data reconstructed from CT scanning, and establishment of a method of implant surgery that is highly reliable.

The substantial number of clinical results of the AQB implant that have been accumulated by a large number of dental clinicians should not be confined to the limits of this country but spread worldwide; but this has not yet taken place. This could be because we have been pursuing practicality over fame; it is hardly likely that I alone am disappointed by this.

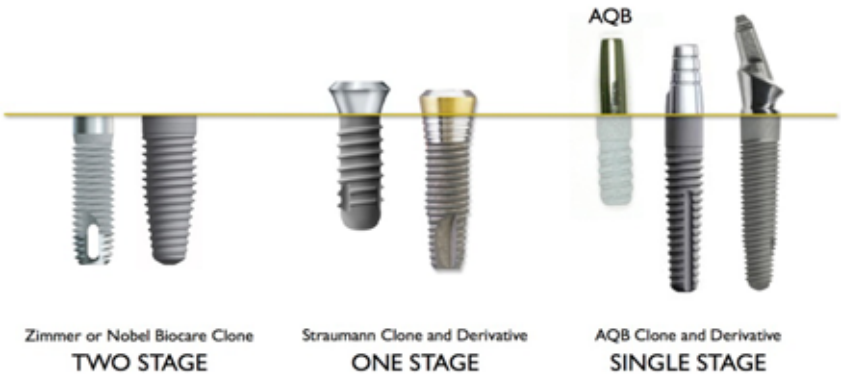

Fig. 1-1-9
Many clones or the modifications of the two-stage type implant represented by the Zimmer and Nobel Biocare (left), and the one-stage type implant represented by the Straumann System (center), have been placed on the market. The single-stage type AQB Implants (right) were also derived from the Nobel Biocare and the Zimmer models.

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