Rev. Port. de Est. e Cir. Maxilofac.
33 (2): 63-69

IMPACT OF OSSEOINTEGRATION ON FUTURE DENTAL EDUCATION

Prof. P-I Brånemark

Dentistry in the future will primarily deal with prophylaxis against caries and diseases of the periodontium. Partial and complete edentulism in the industrialized world will whenever economically feasible be treated with fixed prosthetic devices.

Since osseointegrated intraoral reconstructions have been demonstrated to provide predictable long term clinical function at reasonable cost and effort, it is necessary that dentists of tomorrow obtain adequate basic information about the principles and indications for this treatment modality already early in their studies (Brånemark et al., 1977, 1985).

Introduction of the concept of osseointegration in dentistry

Procedures to reconstitute the original dentition should be considered against the question whether teeth are disposable or not disposable, whether retrievable or not retrievable. In this context Cervante's statement in Don Quixote "Every tooth in a man's head is more valuable to him than a diamond" constitutes an important added requirement and motivation for maintenance of the original, biologic components.

However, if a single, several or all teeth for various reasons have been lost, there is now a therapeutic possibility to restore the patient to a fully dentate and functioning state. This paper will deal with the anatomy of education in osseointegration, but will start with the anatomy of osseointegration as a biotechnological phenomenon.

There are many different situations when anatomical and physiological defects in the human body have to be provided with prosthetic substitutes instead of repair by biologic material. Two basic requirements have to be considered for any kind of endoprosthetic replacement, namely mechanical stability based on attachment of the prosthesis to living remodelling bone, and no adverse bone tissue reactions. In the case of external prostheses there is an additional requirement on non-reactive penetration of skin or mucuous membrane to provide connection of the prosthesis to the anchorage element incorporated in the skeleton (Fig. 1).

Transfer and distribution of functional load across the interface as well as the impact of the internal and external environment are crucial factors for the long term prognosis of the reconstruction.

In the past the term Dental or Oral Implants has been used to identify various hard ware components, in most cases not recognizing the fact that in addition to adequate anchoring elements the decisive factor for a predictable long term prognosis is the surgical and prosthetic handling of hard and soft tissues. Osseointegration procedures must be introduced and applied in daily dentistry based on this fact, which in addition to a systems approach in treatment also requires a logical and rational organization of treatment resources (Fig. 2).

Osseointegration can be defined related to biological, mechanical or clinical considerations. It means that a carefully designed component of pure titanium with a specific microsurface can be incorporated in living remodelling bone with non-inflamed mucousal tissue at abutment penetration (Fig. 3).

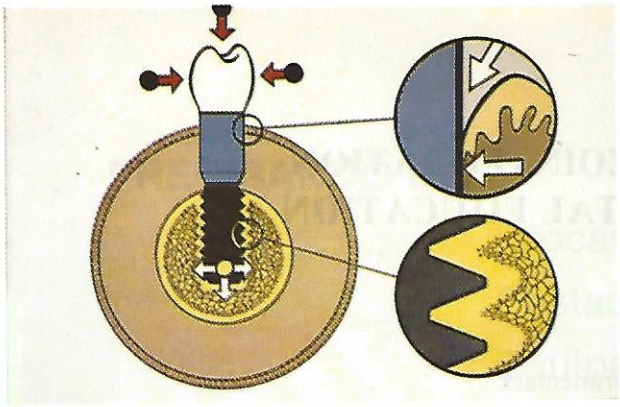


Fig. 1 — Diagrammatic summary of crucial problems in creating permanent tissue anchorage of prostheses penetrating skin or mucous membrane. Reliable stability must be achieved by incorporation of the anchorage element in normal bone tissue providing both adequate resistance to load and load distribution resulting in bone remodelling. Penetration through skin or mucous membrane to allow attachment of external environment in the anchorage region. An anchorage unit consists of nonbiologic anchoring elements together with its incorporating hard or soft tissues. (from[2]).

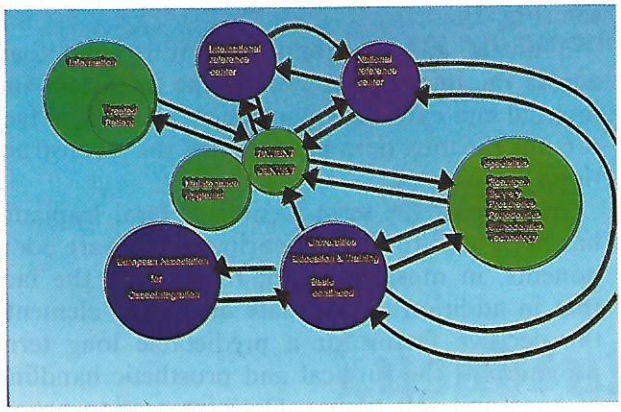


Fig. 2 — A suggested network for clinical application of osseointegration.

For the correct clinical decisions to be made, whether the patient should be provided with a stable substitute for teeth or some other prosthesis, the following definition of osseointegration on a mechanical basis seems relevant:

An implant is said to be mechanically osseointegrated if there is *no progressive relative motion of living bone and implant under functional levels and types of loading for the entire life of the patient.*

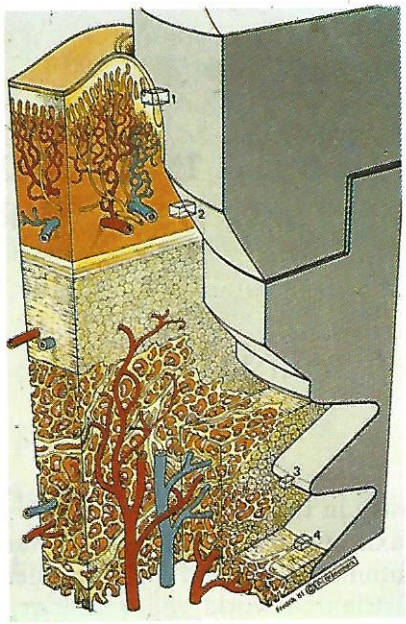


Fig. 3 — Three-dimensional diagram of tissue-titanium interrelationship showing an overall view of the intact interface zone around osseointegrated implants. (from[2]).

Accordingly, load via the titanium fixture is transferred to the anchoring bone without any intermediate soft tissue. The interface between titanium and biologic components can be described at different levels of resolution, ranging from the molecular dimensions to microscopic anatomy.

Lasting osseointegration can be obtained if a gentle surgical procedure is used to create a congruent recipient site in the bone tissue, allowing this bone to heal as if it had been the site of a fracture or an osteotomy.

Subsequent remodelling of bone resulting in improved mechanical capacity because of increased density and mineral concentration supports long term predictability. Biopsies from clinical situations verify this behavioural pattern of anchoring bone showing apposition of dense bone towards the titanium threads.

The prosthetic replacements for teeth are retrievably connected to the integrated titanium fixture in a micromechanical device.

Because of the combination of synthetic and biologic material the treatment must be based on

recognition of a crucial time factor for healing and remodelling of the hard and soft tissues of the edentulous jaw. The long term prognosis with requirement not only on adequate stability, but also healthy mucoperiosteum, relies on maintenance of a dynamic equilibrium (Fig. 4).

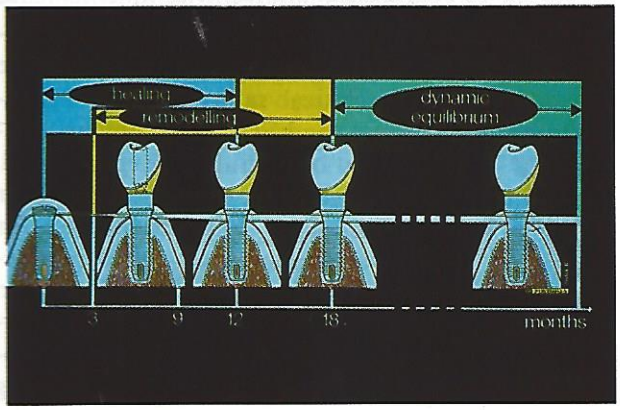
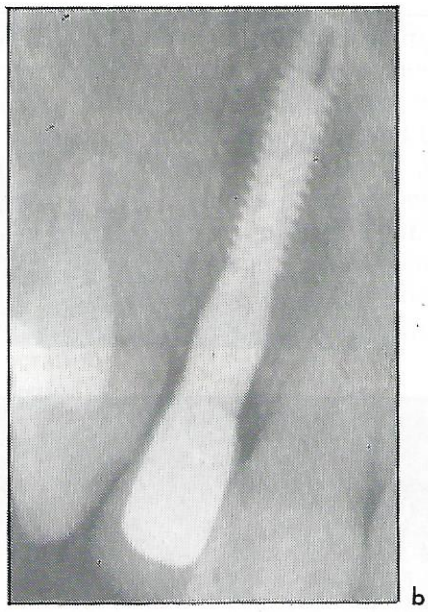


Fig. 4 — Diagram summarizing sequence of events in tissue incorporating and integrating the titanium fixture. (from[2]).

Replacement of a single tooth (Fig. 5a-c) or a substitute for an entire dentition requires the same careful prosthetic planning and attention to detail in surgical and prosthetic technique as well as respect for the biologic time-base: healing and adaptation of the hard and soft tissues. Cases of partial edentulism call for individualized surgical and prosthetic procedures (Fig. 6a-b).

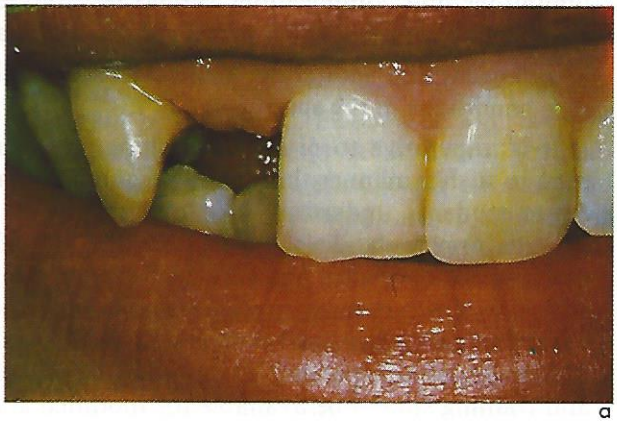
Whatever kind of defect the prognostic expectations should include continued stability of the prosthesis, no significant complications and reasonable requirements on revisions. Prognostic predictability can only be evaluated if reports from unbiased multicenter studies are available, if these clinical reports are based on objective criteria for sucess and failure.



b

c

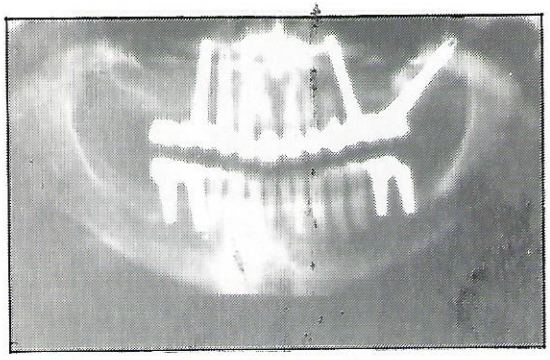
Fig.5.a-c — Replacement of a single anterior tooth according to the osseointegration principle.



a

Osseointegration, since its clinical introduction in 1965, has been applied on 100 000 patients with installation of 500 000 fixtures. In edentulous cases with normal defect anatomy 10 year results have been reported with 95% continuous stability of a fixed prosthesis in the upper jaw and 99% in the lower jaw (Albrektsson et al., 1986).

Since the quality of the clinical results obtained



a

b

Fig. 6.a-b — Demonstrate possibilities to provide a fixed restoration in upper and lower jaw in a case of partial distal edentulism.

is directly related to the capacity of the dentist, it is a crucial question to consider who should provide teaching, training and examination. In a combined situation of a systems approach with hard ware and soft ware closely related to each other, a health care procedure must be based on an interaction between research and industry. This cooperation must be based on trust, consultation and mutual understanding between commercial companies and universities.

When it comes to actual teaching and training in clinical procedures, it is imperative that university or specialist clinics with their own clinical experience of the procedure provide initial and continued teaching. It is imperative that osseointegration as a treatment modality becomes an integrated part of teaching and training in dentistry. This in turn requires that courses in basic principles and clinical procedures are provided, but also that as soon as possible this kind of therapy is included in the curriculum of the dental universities.

The teaching program must consider that the soft ware requires basic, advanced and continued educational efforts. The various hard ware components available from commercial companies or being developed as new or modified technology at research or commercial laboratories must be carefully evaluated and followed over very long periods of time before their clinical safety can be established. Until clinical safety has been documented even minor modifications from an established system should be considered experimental.

I would like to suggest that one should consider formation of a European University Group for teaching, training and examination in osseointegrated prostheses. The already existing European Osseointegration Training Center at the University of Leuven, Belgium, and the European Association for Osseointegration could be supporting resources in this respect.

Since osseointegrated oral reconstructions are now routine clinical procedures, it is also important that material for education and training is made available in form of textbooks, manuals etc. The training should be based on the philosophy of a team approach with the patient and practitioner as a basic unit with a possibility to involve or consult various specialists at critical stages of treatment planning or performance (see Fig. 2).

In the program there should also be allocated training time for clinical application of the surgical and prosthetic procedures in carefully selected cases. It is crucial to identify what kind of defects that can be safely and rationally reconstructed by a well trained and motivated general practitioner and in what situations the patient should be referred to a specialist. Indications, contraindications, limitations and complications should be considered in detail. Printed, video and hands on material is important and should be adapted to the health care conditions in the specific country.

It is imperative to organize teaching and training in such a manner that graduate and postgraduate students understand the philosophy of a systems approach. This means selection of safe and proven hardware but with concentration on software, which requires precision in handling and maintenance of hard and soft tissues and careful follow up of the patient. Continuing education and training should be available for modified and

new intra- and extraoral application of osseointegration, e.g. in rehabilitation of congenital defects, aplasia, dysplasia, injuries, combined procedures, e.g. guided tissue regeneration in orthodontics etc.

Development of components and materials for tissue anchorage and prosthetic superstructures as well as basic research on the biotechnological mechanisms of osseointegration should be updated in addition to current textbooks but also be made available to dentists in special courses.

The necessity of cooperation and communication in an interdisciplinary approach should be the common denominator in all these teaching activities.

It is important to provide the patient with full information about what to expect of the treatment, but also the possibility of problems. The requirement on long term maintenance should be particularly emphasized. Related to the individual patient with a structural and functional defect, different specialists may be consulted. However, a long term maintenance program should preferrably be controlled by a practitioner within reasonable geographical distance to the patient.

If complications in treatment occur or if the patient's defect requires special clinical experience or instrumentation, it is important that the patient can be referred to a clinical center where more complicated procedures can be provided, such as autologous bone grafts etc.

Each patient should be critically evaluated related to procedures that could possibly be beneficial. A selection of therapy and advice on treatment should be based on established reliability but also on whether the procedure can be safely applied in the case of the individual patient.

The requirement should be to provide lasting anchorage with minimal surgery and adequate prosthetic precision. Surgical procedures intended to provide prosthetic stability should be preceeded by careful presurgical prosthetic planning. Estimated requirements on maintenance and adjustment must be considered. Before a decision is made on treatment there should be an over-all evaluation of whether it is beneficial, cost effective and affordable. It is equally important to inform the patient about who is responsible for the treatment provided in the short and long term perspective.

Particularly in an area with a history like that of dental implants and a future of oral and maxillofacial endoprosthesis it is important to identify what is academic hypotheses and speculations or clinical realities and subsequent responsabilities. It would seem obvious that even minor surgical procedures in the oral cavity should require some basic training in surgical technique and how to avoid or handle inevitable anatomical and technical problems.

Elective clinical procedures require considerations on what to do, if treatment fails, or rather how to avoid failures. Crucial items are: who to blame, choice of method, adequate procedure, prognostic predictability, experienced doctor, patient cooperation.

The question: to treat or not to treat an edentulous patient is usually fairly easy. However, one must remember that there are situations of technical sucess but clinical failure, e.g. in a case of dysmorphoparanoia. There are also situations where it could be a mistake to treat because of inadequate technical capability of the doctor or a psychological problem in the interaction between patient and the doctor that cannot be resolved, or because the patient has other psychological problems that constitute his real concern.

There are, however, also situations where it is a failure not to treat: if the patient presents with difficult anatomy or difficult behaviour. Successful treatment may require referral of the patient, sometimes to different specialists. It is crucial not to exclude the patient for these reasons. With careful and detailed exploration of the patient's local and total situation, the number of avoidable problems should be minimized. Non-avoidable problems inherent in a surgical/prosthetic procedure should be identified and taken care of as soon as possible, which requires an ambitious monitoring program. Despite all efforts there are bound to be failures and their consequences must be seriously considered. It is a minimal requirement that even if an elective treatment fails, the postoperative conditions should never be worse than the preoperative situation.

Figs. 7a-c illustrate a case of combined maxillary defect that requires participation of various specialists in order to secure reasonable prognostic predictability.

Additional odontological specialists may be involved in the use of osseointegrated procedures. The fact that the titanium fixture is directly connected to bone without any intermediate soft tissue has been proven to allow for using osseointegrated components as anchor points for orthodontic movement of teeth.

Treatment of hypodontia, anodontia and ectodermal displasia obviously should be performed in close collaboration with orthodontic expertise with individualized timing of the different steps of treatment, recognizing the need for careful attention to the three-dimensional growth of the craniomaxillofacial skeleton.

The vast majority of patients that the general dentist will diagnose and arrange treatment for

a

b

c

Fig. 7.a-c — This patient as a consequence of ressection of a tumour had an anterior maxillary defect in combination with loss of the upper lip. Titanium fixtures provided anchorage for a metallic bar supporting denture and orbiturator. In addition, a prosthesis for the upper lip was connected via a magnetic attachment.

are of course related to straight forward edentulism. There are also a number of patients with more complicated defects — intra- and extraoral that will consult their ordinary dentist in order to get advice. It is therefore important that even extraoral prosthetic problems are included in the training protocol, such as retention of an ear prosthesis. More complicated or unique combinations of defects obviously require very special surgical and prosthetic procedures which should be part of the training program for specialists in maxillofacial surgery and prosthetics.

In a situation where osseointegrated reconstructions have become accepted as a treatment modality (Editorial, Lancet, 1990) and where bone anchored implants in the head and neck region (Hallén et al.,· 1988) are available for extraoral retention of various kinds of structural and functional prosthetic substitutes, there is a strong motivation to consider dentistry and medicine as joint contributors to health care. For the intraoral application of osseointegration it would seem rational if a similar educational program could be developed for world-wide application in dentistry.

REFERENCES

1. BRANEMARK, P-I, HANSSON, B.O., ADELL, R., BREINE, U., LINDSTROM, J, HALLÉN, O. and OHMAN, A.: Osseointegrated implants in the treatment of

the edentulous jaw. Experience from a 10-year period. Scand J Plast Reconstr Surg suppl. N.º 16, 1977.

2. Tissue-Integrated Prostheses. Osseointegration in Clinical Dentistry. Eds.: Branemark, P-I, Zarb, G.A., Albrektsson, T. Quintessemce Publi. Co., Chicago, 1985.
3. ALBREKTSSON, T., ZARB, G., WORTHINGTON, P., ERIKSSON, A.R.: The long-term efficacy of currently used dental implants: A review and Proposed criteria of success. Int J Oral Maxillofac Impl 1:1, 11-25, 1986.
4. HALLÉN, O., MAGNUSSON, S., JACOSSON, M., MARKÉ, L.-A.: Bone-anchored implants in the head and neck region: Report from a State of the Art Conference in coop. with the Swedish Council on Technology Assessment in Health Care and the ENT Dept at the Univ of Gothenburg, Sweden.
5. Osseointegrated dental implants here to stay. Editorial Lancet vol. 335, 1190-1191, 1990.