Stefan Ihde

# Principles of BOI

Clinical, Scientific, and Practical Guidelines
to 4-D Dental Implantology

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## Clinical, Scientific, and Practical Guidelines to 4-D Dental Implantology

With DVD

With 388 Figures and 8 Tables

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Beyond all this, my special thanks are due to the tireless critics of the BOI treatment who have encouraged me and many other practicians of basal osseointegration implantology to enter into an open and critical exchange with the protagonists of crestal implantology. They have often failed to appreciate and continue not to appreciate the fundamentals of this treatment concept, and by doing so have stimulated me to lay out in detail the theoretical foundations of bone behaviour following BOI therapy, based on a review of the extant literature and on many years of clinical experience, during which we had the chance to treat far more than one thousand patient cases. Comparative examination of the principles and procedures of crestal implantology have shown that this area is replete with theoretical and practical inconsistencies. This book will point out several of these inconsistencies.

Clinical observation of unexpected and undesirable treatment outcomes provided permanent motivation for further research into the procedure of basal osseointegration per se and of pertinent implants, tools and treatment strategies. Cordial thanks to the team at the Gommiswald Dental Clinic, whose good ideas and commitment helped me keep up my motivation throughout all these years.

Most of all, I would like to thank my family for their understanding and support as I was deeply immersed in this endeavour, often under great tension and all too often not even present. May all our hopes for imminent improvement on that front not be in vain!

August 2004 Stefan Ihde

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# Struggles and Successes

*Implantology is, like chess, governed by the laws of Nature. We cannot see our opponent, but we know that she is fair, honest and patient. Adapted from Warrior of the Light: A manual by Paulo Coelho*

## 1.1 Struggles

When too many people agree on the same subject, it is high time to call it into question. Few other areas of medicine are better characterized by this statement than dental implantology. Why? Because both academic "researchers" and practitioners focus their efforts solely on crestal implants. In other words, they completely ignore any designs or concepts other than screws and cylinders, which guide the masticatory forces, into bone areas that mainly consist of cancellous tissue. If the available vertical bone supply is insufficient, measures are taken to rebuild the morphology of the bone tissue – whether by transplantation, by augmentation or by induced growth. Unless aesthetic considerations play a major role, these modifications of the bone situation are performed solely to facilitate the use of crestal implants, which would be impossible to insert otherwise. In many cases, these adjuvant measures are considerably more time-consuming and more expensive than the patient can afford. Meanwhile, no implant treatment is performed *whatsoever,* and the patient is left without an adequate fixed restoration. At the same time, the focus of dental implant treatment tends to shift away from the dental offices as these adjuvant measures gain respectability, towards the specialists capable of performing them. Due to the additional cost of these adjuvant measures, many patients are unable to afford adequate implant treatment. The consequence is that their masticatory function cannot be restored in a truly comprehensive manner.

The implant technique of "basal osseointegration" (BOI) has been developed with a view to addressing the situations outlined above, among other problems. In this book we are going to explain why lateral access to the jaw bone should be the standard technique in dental implantology. Conventional implant designs can occasionally be used as additional treatment options.

Some dental "experts", sharing neither the vision nor the experience of BOI users, have in the past raised vocal opposition to this system. It is not uncommon for traditionalists, who once rose to fame by using specific methods, to eagerly oppose the obsolescence of their knowledge by obstructing progress actively. In their capacity as court-appointed experts, they can literally boycott new treatments for a long time.

Due to an almost religious belief in scientific medicine – it has been argued that this belief is a substitute for religion itself (Lütz 2002) – patients are often unable to inform themselves in a realistic manner about novel treatment modalities. Nevertheless, BOI implants have become increasingly popular in recent years. As a result of the high degree of patient satisfaction, the patients ultimately "vote with their feet".

No doubt, treatment with BOI implants can only be performed and its outcome evaluated in a competent manner by users who have been thoroughly trained in the technique and are up to date on the current experience. Anyone rejecting the technique out of hand will of course never be able to acquire and master it. We shall therefore present the BOI technology in this book, demonstrate its practicability, and document its successful outcome based on specific case reports.

Dentists who perform BOI treatments are still required to have additional solid training. What we are currently observing is that more and more universities are becoming active in this field, having first acquired the technique themselves. Since the universities' raison d'être is the propagation of knowledge, this development of course deserves praise. By contrast with most current teachings in the realm of crestal implantology, the propagation of knowledge about the real-life properties of bone and its behaviour play a prominent role in BOI. Of equally great importance are prosthodontic concepts and the teaching of how to restore the human masticatory function. Many universities were too late getting on the BOI train. One might well ask how this could have happened – several factors come to mind:

- A comprehensive concept of mastication is absent from the academic teaching curriculum. Some universities do not currently teach this field at all, while others teach quite divergent views.
- The teaching and practice of dental implantology is spread across several departments: prosthodontic

departments implant "simpler" cases, departments of oral surgery implant "more difficult" cases, and the maxillofacial surgeons are holding their own when it comes to maintaining their niche in maximally invasive bone transplantations. Even orthodontists occupy a small region within dental implantology related to enossal anchorage. Needless to say, all these departments fight each other for access to the few patients and to third-party research grants.

- In a way, BOI implantology is a part of all of these subfields, an interdisciplinary endeavour, focussing on functional therapy and with a strong surgical aspect. Psycho-social and economical aspects also play a role: Not only is the BOI procedure the fastest and safest treatment procedure in dental implantology today, it is also the cheapest.
- Some universities increasingly realize that post-graduate instruction in BOI implantology is an immense field that might very well generate huge amounts of financial resources. Students from all the sub-disciplines cited above need some training in BOI implantology – and ultimately all active or future dentists.

During my BOI-related travelling activities, I have found that fellow dentists in the ex-Communist countries are much more familiar with the basics of bone physiology and mastication therapy than dentists in the former Western countries. However, interdisciplinary training seems to be scarce at some institutions.

According to Scortecci (2001), 99% of patients not eligible for treatment with screw implants can be treated by BOI without bone transplantation. This high success rate is in accordance with our own experience.

At present, insurance companies are beginning to find out that BOI treatment is by far more safe, faster and cheaper than conventional bone augmentation followed by crestal implantation. On the other hand, the appearance of BOI on the stage means that more patients will undergo treatment more readily: a great number of patients who have toyed with the idea of implant treatment before but shied away from bone transplantation or prolonged chair times are beginning to see a realistic chance of obtaining fixed restorations on implants within an acceptable timeframe.

It is necessary and fair to mention that disk implantology and the BOI technique, like all dental implant techniques, went through an early phase of treatment failures with implants and prosthetic superstructures being lost. The same learning curve had to be mastered in the development of all other implant techniques or, for that matter, any other medical treatment. Many problems in connection with basal osseointegration arose from the fact that a number of views on procedures, believes and treatment approaches were adopted from untested crestal implantology. They were adopted without knowing the reasons why the original technique had actually worked, or not worked, in specific cases. In our view, some of the "rules" that evolved from the literature on crestal implantology are definitely wrong. Some of them cannot be generalized but are based solely on empirical observations that may possibly apply to crestal implants. Anyway most of them had to be revised in the past decade.

## 1.2 Other Major Considerations

Learning the surgical procedure is not difficult *per se* if good instruction is provided. Trainees have to need to shake off several prejudices that are considered widely to be facts.

1. A common misconception today is that the lateral osteotomy for BOI cannot be created with the same low-speed instruments as commonly used in crestal implantology. Regardless, however, there are great advantages in using high-speed instruments and ultrasonic tools not only on teeth, but also in the bone.
2. The claim that the temperatures associated with high-speed instruments will affect bone healing is defeated by clinical experience.
3. The concept of immediate loading with BOI implants is continually discussed under false premises, as most concepts of crestal implantology rely on unloaded osseointegration of implants. Crestal implants, especially in the maxilla, are inserted in bone areas that consist mainly of cancellous tissue. These areas are not capable of accepting and transmitting masticatory loads in the early phases of treatment. This only becomes possible once the bone tissue has been adequately conditioned by the endosseous implant surface. Chapters 9 and 23 will provide the reader with the necessary background to weigh up the pros and cons of immediate loading more realistically.
4. The claim that implant placement is contra-indicated in periodontally involved areas is also based on false premises. In crestal implantology sterile insertion is a major requirement since no gap is left for suppuration. Pre-existing residual osteitis within the bone or micro-organisms introduced during the insertion can bring treatment with crestal implants to an end very quickly. BOI implants, by contrast, are highly resistant to infection. The reader is referred to Chapters 8 and 23 for a detailed discussion of this issue.

## 1.3 Anatomical Landmarks as Moving Targets

The BOI technique requires not only a three-dimensional concept of the structures of the human skull, but also a notion of the morphological changes that the skull will undergo both with age and as a result of the planned treatment. The experience with BOI implants has yielded empirical guidelines that predict where an implant should be placed, how it should be put into function by prosthetic means and what types of treatment will ensure a successful outcome.

Even though a sustainable implant site may be unusable at the time of first implantation, the treatment can still be planned in such a way that the required bone volume will be building up under a long-term temporary restoration. Tricky concepts like these are a challenge in our everyday practice, but ultimately they are logical. The successive treatment steps are easy to perform in the hands of well-versed practitioners.

Additional difficulties arise in situations with a mineralization pattern not consistent with to what would "normally" be expected, or with an adequate bone volume not being present at strategically favourable implant positions. This may occur at the beginning of or during a treatment. Ultimately, the goal of treatment is to create stable conditions even though the functional potential at the beginning of treatment may be such that stability cannot be attained immediately.

## 1.4 Winds of Change

At a time when cars are built to last, with fully galvanized or all-aluminium chassis for corrosion protection – it is difficult to explain to some patients that definitive prosthetic restorations, once they have been inserted in the mouth, need to be adjusted periodically to ensure their longevity in a visco-elastic intra-oral environment that is subject to continuous mechanical and static changes. Also, the fact that implant treatments are relatively expensive leads patients to believe that they can expect a stable definitive product in return for their money with no need for subsequent maintenance therapies. Patients would like to think that their own collaboration is no longer a major factor in the outcome of the bone-implant-restoration complex once the installation phase has been completed. They tend to overlook that cars, too, need regular maintenance and checking and are periodically fitted with new tyres to resist a mechanically hostile environment. In cars, the maintenance costs are a substantial portion of the acquisition cost.

Implant-borne restorations need maintenance and so do the implants themselves. The frequency of these visits will depend on how unusual the case was at the time of presentation and how fast the masticatory system can be guided back to regular function.

Sustainable implantological results can only be obtained if the implants incorporated into the functional complex of the skull do not affect the functional morphological changes of the jawbone. Preferably, they should be placed in areas where the bone is safe from resorption, so that enough volume will be available for many years to come. These safe regions include not only the mandibular anterior segment but other areas as well. Crestal implants, however, cannot be placed in these areas (e.g. because of the mandibular nerve) or, at best, require awkward adjuvant procedures to be inserted. In these cases, BOI implants are a simple alternative to realize a fixed restoration after all. Lost bone structures will rebuild by themselves wherever functional loads induce them to rebuild or, for that matter, wherever the dentist ingeniously directs these functional loads. Therefore, the long-term success of treatment in terms of bone gain will depend much more on the prosthetic restoration than on the surgical procedure of implant insertion. Implant sites that are basically stable may "suddenly" lose their stability if the functional pattern of the masticatory system changes adversely. These interactions are not self-explanatory. The reader is referred to Chapters 9 and 10 for a detailed discussion.

Extensive bone augmentation procedures, although really unnecessary, are still being performed. The persistent use and propagation of those techniques has in effect become a hallmark of dental implantology. Almost all patients would be eligible for fixed restorations if only the implants were selected to match the bone. The effectiveness of BOI as a treatment option has been well established for a long time. Here, "effectiveness" means the ability to restore a balanced masticatory function. The question whether this objective can be achieved and maintained constitutes the only basis for verifying the desired "effect". The goal must be to minimize the number of surgical procedures and to ensure a good masticatory function based on fixed restorations at all times, even during difficult treatment phases.

A solid understanding of the BOI technique requires a firm grounding in biomechanics, bone function and mastication. With this in mind, the reader may want to read Chapters 9, 10 and 23 first.

## 1.5 The Rocky Road to Success

Today, implantological treatment goals can be achieved more reliably, more easily and less expensively than ever. Well-versed practitioners have the option of using BOI implants, which are the state-of-the-art descendants of the first-generation T3Ds,[1] the second-generation disk implants. With BOI implants, fixed restorations can be placed even in severely compromised alveolar ridges. Furthermore, they can be immediately loaded in the majority of cases. Since BOI implants utilize the horizontal dimension of the ridge (which is always intact), the vertical bone requirement is very small.

In the late 1980s, disk implantology was still dismissed as an uncommon technique used only by outsiders. Further developments, however, have given rise to the BOI technique, which today is the most frequently used restorative method to treat advanced ridge resorption in a single procedure, not least because it is the only technique allowing a genuinely one-step surgical approach. The technique has reached an extraordinary degree of maturity because it has been developed, over decades, outside Academia by practitioners only. Also, the fact that manufacturers have embraced the input from clinical users directly and without delay has greatly accelerated the development of the materials as well as of the method.

Meanwhile, the progress made in crestal implantology has been incorporated to the benefit of BOI as well, the developments in surface technology being one example.

Another aspect to keep in mind is that the manufacture of BOI implants became affordable only recently by advanced CNC-controlled technology. This technology and the sophisticated manufacturing techniques associated with it have created the possibility to design stable and delicately shaped implants from titanium ingots with known basic properties without significantly altering the structure of the material (Figs. 1.1–1.7). We are indebted to the engineers who were skilful enough to translate our requests concerning implant design into finished products.

Crestal implantology no doubt offers optimal ways of restorative treatment in situations where the implants can be inserted without delay and with no need for adjuvant procedures. Unfortunately, a great many patients do not meet these criteria. This is particularly true of the posterior segments of the maxilla and mandible. Whenever oral conditions are less than ideal for crestal implants, the advantages of the BOI approach are obvious:

- Low degree of invasiveness (no augmentation, distraction or transplantation)
- One-step procedure
- Simple repair in case of problems
- Combination with natural teeth possible
- Combination with crestal implants possible
- Manageable system (few components)
- Simple laboratory technique
- Extremely high success rates

**Fig. 1.1.** Advanced CNC milling machines are capable of shaping many different BOI designs with defined properties from a single bar of massive titanium

**Fig. 1.2.** View of the manufacturing chamber of a CNC milling machine

[1] The first tridimensional implants were designated "T3D" by Jean-Marc Julliet.

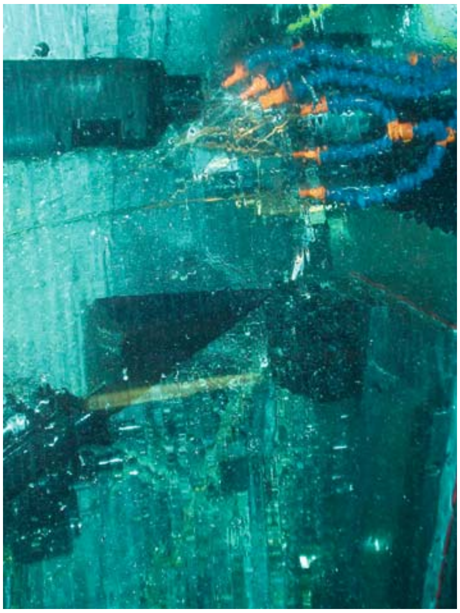

**Fig. 1.3.** It is impossible to watch the milling steps due to the extensive cooling requirements

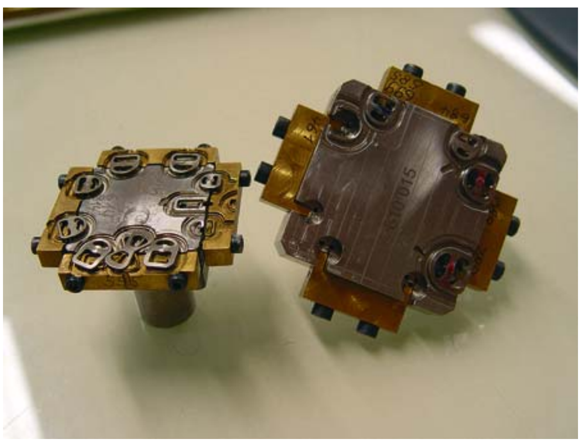

**Fig. 1.4.** Some BOI designs need to be adjusted in a second and third step by abrasive instruments. For this purpose, they are mounted on individual tray compartments

**Fig. 1.5.** The same triple-disk BOI design in different stages of processing

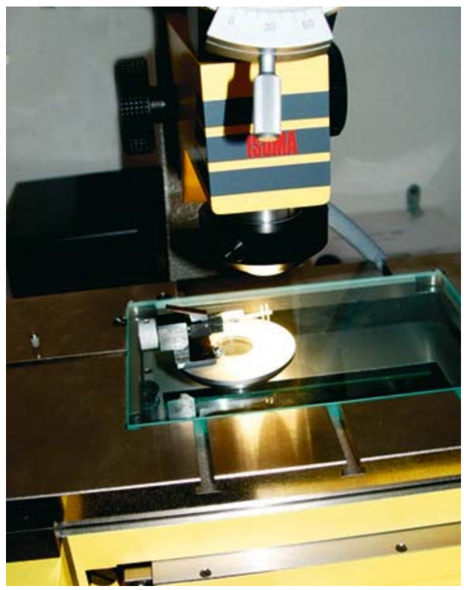

**Fig. 1.6.** Although CNC milling machines are extremely accurate and precise, each specimen is thoroughly inspected

Disadvantages of the BOI system include:

- The stock-keeping requirements are greater than in crestal implantology, i.e. it will always be necessary to keep a few more implants handy to avoid extensive planning including three-dimensional exploration of bone conditions.
- The technique poses substantial challenges, for instructors and users alike, as far as the surgical and prosthetic treatment stages and the substantial knowledge requirements in the fields of biomechanics and bone physiology are concerned.

From a business perspective, however, these disadvantages turn out to be advantages after all, since mastering the learning curve will give dentists a comfortable edge over any competitors in the field of implantology.

The question why the outcome of BOI implants is so much better than the results with crestal implants – which specifically includes the survival rates as well – remains to be conclusively answered. Presumably, the prognosis of BOI implants is better from the start, as the blood supply to the bone remains largely intact as a result of the "skeletized" enossal implant fixture. Surface-enhanced crestal implants are susceptible to peri-implantitis, which

**Fig. 1.7.** An extremely motivated and well-trained team of CNC specialists guarantees reliable quality in the production of BOI implants. During the production phase, any effort must be made is to leave the structure and the strength of the titanium and its elastic properties unaltered

may lead to progressive ridge resorption. With the BOI technique, this is less of a problem due to the narrow polished emergence of the implants. In addition, the site of bacterial invasion is far away from the site of force transmission. Hence the bone is not burdened with two tasks at the same time. Crater-style collapses are usually avoided this way. Moreover, the implant areas where load transmission takes place are integrated in such a way that the osteogenetic and osteoprotective properties of the cortical bone are optimally utilized.

In BOI systems, the fate of the alveolar ridge is not linked to the fate of the implant-restoration complex, since the areas where load transmission takes place are spatially separated from the masticatory surfaces. This fact is obvious from the very design of BOI implants. For successful insertion and load transmission, it is irrelevant whether the vertical portion of the implant is embedded in air or in fluid. It is also irrelevant whether bone tissue is deposited directly on the implant surface in this area. This has many desirable implications:

- Aesthetic considerations aside, the success of implant therapy does not depend on the presence of alveolar bone.
- In the presence of dysgnathia, masticatory surfaces can be installed at sites that are spatially independent of the skeletal base.

A good emergence profile of restorations on external BOI systems is achieved by workaround solutions due to the small diameter of the threaded pin. For this reason, BOI implant restorations in the aesthetic zone are somewhat harder to realize than with crestal implants (provided there is enough vertical bone to place them) and require a good measure of anticipation on the dentist's part for correct positioning of the abutments.

Treatment success depends to approximately 80% on prosthetic concepts and their execution and maintenance and only to 20% on the surgical procedure. And it depends on reliable, good compliance of the patients. The patient must be informed about this and must know that immediate load does not mean the immediate end of active treatment phase.

## 1.6 Scope of This Book

This volume describes the application techniques, surgical approaches, prosthetic methods and maintenance therapies in connection with BOI implants. Some types of force transmission areas are examined by FEM analysis of elastic behaviour under physiologic loading. Healing patterns with or without loading will be compared to those of screw implants based on animal experiments. Both the FEM results and the impressive histological data presented in this book will make it easier for the reader to develop a basic understanding of BOI technology and the bone reaction involved.

Other chapters deal with specific anatomical situations and how they are addressed with BOI implants. Emphasis has been placed on Angle class III and II skeletal relationships, on resorbed mandibular ridges, on cantilever situations, and on treatment options in the posterior segment of the maxilla. Treatment concepts relying on multiple implants are compared to strategic implant placement.

An entire chapter is devoted to the theoretical basis of immediate loading. This will include a critical review of the literature referred to by crestal implantologists.

The BOI technique is compared to conventional treatment concepts using bone augmentation, bone grafts or osseodistraction. Critical analysis reveals that the conventional multi-step procedures used to augment the maxillary sinus or the distal mandible are no longer acceptable in the era of basal osseointegration. Indeed, they belong to the crueller chapters in the history of medicine and should be abandoned as quickly as possible. This is particularly true of iliac bone grafts for sinus floor augmentation. Against this background, the legal implications of the discussed treatment concepts are compared based on current legislation in Germany, the European Union and the United States.

*Repetitio est mater studiorum.* Facts that are relevant in different connections are repeatedly explained in this book with shifting emphasis depending on the context. This allows the reader to start reading wherever he or she pleases, and it ensures and elucidates the continuity of related chapters.

## 1.7 Evidence and Trust

Medical writing must be based on evidence. This is an indispensable requirement because evidence is the only way of obtaining certainty. These certainties obtained by way of evidence are more likely to stand the test of time – at least parts thereof – and provided that the questions and perspectives from which they were derived stand the test of time as well. Of course, this presupposes that the authors were honest in the first place.

”BOI technology is not based on scientific evidence.” Statements of this kind can be heard time and again from people trying to avoid the trouble of learning the technique and of screening the literature for pertinent reports, which are abundantly present, and to read them. Referring such critics to the piles of existing literature on the subject will usually silence them. Much literature has been extensively studied and evaluated for this book. Given the unwieldy mass of dental and medical literature that has accumulated over the centuries, no claim to completeness is made. What is striking in retrospect is the fact that a substantial basis of knowledge that is no longer a part of current dental training was already disclosed by early authors who have more or less fallen into oblivion. The same knowledge reappears in a great number of “modern” publications, the only difference really being in the words used. In retrospect, these early authors – including Wolff, Thielmann, Gerber, Gysi, Frost, Martin and Burr or Planas – laid out the entire armamentarium for BOI a long time ago. However, their various findings and explanations as to the practical implementation of these systems have never been formally consolidated. The present book was written to fill this gap and to encourage the reading of historical articles and books.

This book reflects practical experience and examines it against known concepts in prosthodontics, surgery, and physiology – especially in bone mechanics. The result will be that all treatment methods described here have a sound scientific foundation derived from a variety of dental sub-specialties.

Some of the chapters include bar diagrams with statistical results and overviews without detailing the data pool from which they were derived. These diagrams, unless otherwise stated, are by default based on the total number of consecutive implants inserted at our hospital. The total number of implants detailed in these diagrams will always be based on the latest update of our database and may thus vary depending on the creation date of a given passage. It goes without saying that calculations based on larger samples or longer observation periods will involve a higher level of significance.

Knowledge changes rapidly and has always been in a state of flux. This is not a recent development. The responsibility to keep abreast of developments in dental implantology lies with the reader. As Abraham Lincoln put it so aptly: “A politician can fool most people on almost every issue most of the time, but nobody can fool everybody on every single issue all of the time”. This is as true of authors as it is of politicians – and for the reader to consider.

## 1.8 The Internet

The Internet has paved the way for the breakthrough of BOI technology and will continue to be a major catalyst. There are two reasons for this. For one thing, the Internet has created an opportunity for practitioners to exchange their experiences by transmitting pictures and radiographs, enabling them to join forces in a coordinated manner to work out optimal treatments for difficult cases. Today it is possible to exchange video documentation of surgical procedures, and writings can be disseminated at the touch of a button. It has been said that thoughts, once they have been published on the World Wide Web, can never be extinguished.

For another thing, the Internet has been the first medium through which patients could learn about the mere existence of BOI implants as a treatment option, so that certain obstructionists in our profession are no longer able to suppress the technique successfully. Patients will ultimately "vote with their feet" – i.e. they will walk away from treatment options that are both invasive and expensive (Isfort et al. 2002).

## 1.9 Results and Outcomes (Apples and Oranges)

In the literature on crestal implantology, it is common practice to calculate success rates for implants from their probability of survival. The current statistical approach is to sweep all implants that were lost before being loaded by a prosthetic structure under the carpet. These losses are dismissed as "unfortunate", "infection-related", "idiopathic" or simply as "unexplainable". They never enter the statistics. Neither do the statistics account for implants that could not be installed in the first place, because the adjuvant procedure of bone augmentation or osseodistraction had failed, or for those cases in which an attempt at therapy had not been made because of various "contraindications" connected with crestal implants. In addition those cases have to enter the equation, which have not been treated at all, because the adjuvant procedures were not compatible with the lifestyle of the patients (i. e. housewives who did not want to present themselves to their husbands without teeth during the healing period of the augmentation; or businesmen who stayed with their dentures because they could not afford to stay away from their job for so many appointments).

Also, we have to consider, that quite a few potential patients would be willing to pay for bone augmentations (or BOI!) to get fixed teeth, but they do not want to undergo lengthy suffering.

## 1.10 The Vision

While it is clear that the idealistic notion of all patients having a lifelong right to fixed teeth will never come true, it is also clear that this goal could not possibly be achieved by crestal implantology alone. The various reasons for this have been mentioned previously in this chapter, and they are going to be demonstrated and explained in greater detail throughout this book. It is not only the high costs specifically arising in connection with the invasive adjuvant procedures needed for crestal implant treatment that will often prevent any more extensive implant-based restorations from being realized, but it is also that many patients cannot be treated by crestal implantology altogether, for well-known pathophysiological reasons. This is not to say that crestal implants are inferior, let alone unsuited, in principle. Rather, the highly invasive nature and costliness of the necessary adjuvant procedures are prohibitive to their widespread use. Therefore, crestal implants are clearly not a candidate in the quest for offering dental implants on a broad scale. BOI implants are perfectly able and ready to fill this gap. The present book has been written to support the popularization of this technique.

## 1.11 Listening to Patients' Demands

Patients have the following expectations of implant treatment:

- They want any missing teeth to be replaced at minimum invasiveness in a single procedure; and they want to be through with this problem once and for all.
- They want the entire treatment to be affordable.
- They want all parts of the restoration to be well accessible for brushing and flossing; after all, many of them lost their teeth due to poor oral hygiene. Any bad habits such as smoking and careless brushing/flossing should be abandoned.
- They mainly want to have "fixed teeth" restored; they are not interested in having their bone volume increased and rarely attach great importance to a natural "emergence profile" (a concept overused in the literature), but they simply wish to have their problem solved in a down-to-earth and aesthetically acceptable manner.

In real life, these expectations are rarely met by crestal implant systems (screw implants), due to the following reasons:

- Healing periods are usually long.
- In many cases, several procedures become necessary.
- If bone volume is insufficient, adjuvant procedures become necessary that are usually more invasive and more expensive than the implant procedure itself.
- In addition to being very expensive, these adjuvant procedures carry high a risk of infection or necrosis.
- Despite the large scope of therapy, a considerable number of patients cannot be treated with crestal implants at all.
- Patients treated with screw implants will face intensive oral hygiene requirements.
- Smokers have an increased risk of implant loss.

BOI implants are also a desirable option from the dentist's perspective. The system can be established in the dental office at low cost, requires a manageable degree of additional training, involves a small number of prosthetic components, and offers a high success rate. *BOI implants are a uniquely optimized therapeutic option.* In many situations, BOI systems can be used in conjunction with crestal implants to optimally take advantage of both systems.

Treatment with BOI implants is simpler and quicker than crestal implant therapy since no augmentation procedures are involved. Based on our experience with more than 1,000 patient cases treated with BOI implants, 95% of patients can be successfully treated with fixed restorations in an immediate and definitive manner. In the remaining 5%, a successful outcome can usually be ensured by replacing any failed implants in a secondary procedure. Situations in which a successful outcome cannot be achieved are very rare (about 0.5% of patients). These cases must be carefully analysed and may be treatable after all by using more invasive techniques such as bone grafting as a last resort.

After thorough study of this book, you, the reader, may end up asking yourself, "Why in the world didn't we start doing things like this a long time ago?" If that happens, you will be on the right course. You will successfully circumnavigate the dense fog and steep cliffs often found on the route to dental implantology, and you will not allow yourself to be sidetracked by intentionally misleading beacons. Good luck – and have a pleasant journey!

# History as Documented by Patents and Patent Applications

*Science is the art of creating knowledge*

It has been a long tradition in medicine that new ideas and treatment concepts are hardly ever invented inside the universities. Usually, practitioners – because they really face the patients' problems day-to-day – are the ones to develop new solutions. Not until later are the techniques adopted by universities, and usually it will be necessary, of course, to pay the universities to change their way of thinking, working and teaching. The history of BOI implantology reflects this situation, as can be seen looking at the patent situation in this field. Patents applied for and, of course, patents granted are relatively objective criteria to go by. They help us judge who the people were that have genuinely set scientific milestones and broken with traditional thinking in a constructive way.

By all accounts, the first enossal implant design that relied on a lateral insertion path and capitalized on the stability of the inner and outer cortical bone was devised in Italy (F.P. Spahn, personal communication) The disk and threaded pin were inserted separately in this design, the latter through an extra vertical drill hole. Finally both components were connected with a screw. The technological means for the manufacture of single-unit titanium implants of adequate size were not available at the time.

The first single-unit implant was developed and used by Jean-Marc Julliet (1972). This design was only available in one size and offered no basal plate resilience. In fact, this kind of resilience would have been undesirable, considering that the pin was threaded all the way to the basal plate. The scope of indications for this design was limited to areas where the basal plate reached both cortical structures, so that its use was essentially confined to the anterior segments of either jaw. Incidentally, the threaded pin was only available in one standard length and had to be reduced by the user as needed. It is interesting to read Julliet's description in the patent specification. Julliet clearly recognizes the disadvantages of implant placement without cortical support: Julliet explains that, contrary to Linkow's approach specified in U.S. patent 3,465,441, the gingival resistance and the tight pressure fit of the blade implant will soon give way to masticatory pressure. In this way, the blade is pressed deeper into the bone and will eventually lodge right on the cortical structure. Obviously, Julliet had been closely observing the consequences to be faced when enossal implants lacking cortical support are mobilized by the prosthetic superstructure. He stated that his invention was aimed at creating a reliable type of anchorage that was simple in design and easy to insert. Julliet, however, did not really realize the importance of bicortical anchorage and the possibility of the isoelastic incorporation of a jaw-implant-restoration system.

To summarize, while the original implant design by Lobello was based on inserting two separate components, the design by Julliet featured a welded joint between the threaded pin and the basal plate. His lateral implant was granted a U.S. patent (Julliet 1975). Presumably, the only thing that Julliet had in mind was to use his own idea as inexpensively as possible. He wanted to avoid a situation in which someone else applied for a patent on the basis of his thoughts and ideas, later preventing him from using his own implants.

Some years later the French dentist Dr. Clunet-Coste (1975) applied for a patent on the manufacturing technique of a T-shaped single-unit implant, which showed some of the same essential characteristics as the design described by Julliet in 1972. The French patent was granted and remained effective until its expiry in 1996.

The rights of patent were acquired by the Eugen Kühlmann company through its subsidiary Zerca that continued to market this implant design for many years. This is also where Julliet obtained his implants.

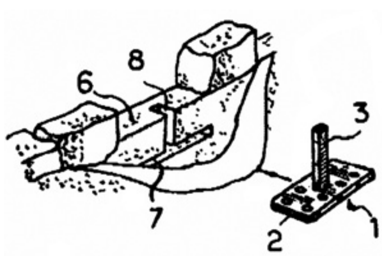


**Fig. 2.1** Drawing from USP 3,925,892

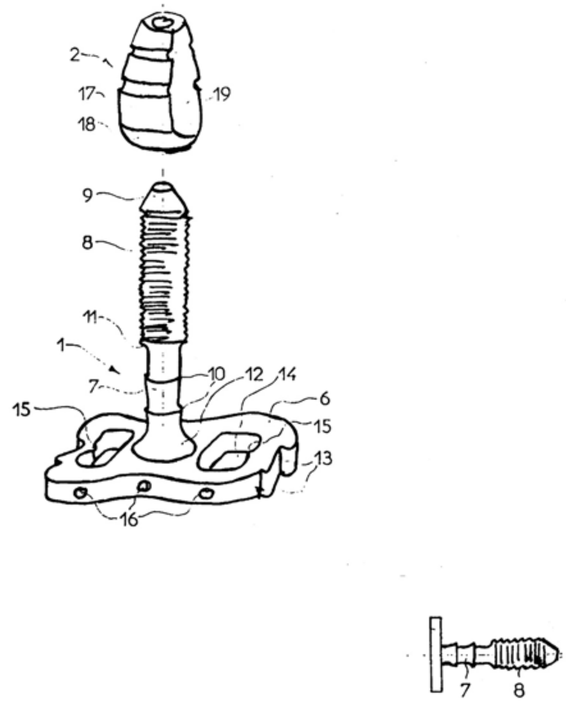

**Fig. 2.2** Implant design by Dr. Clunet-Coste, France

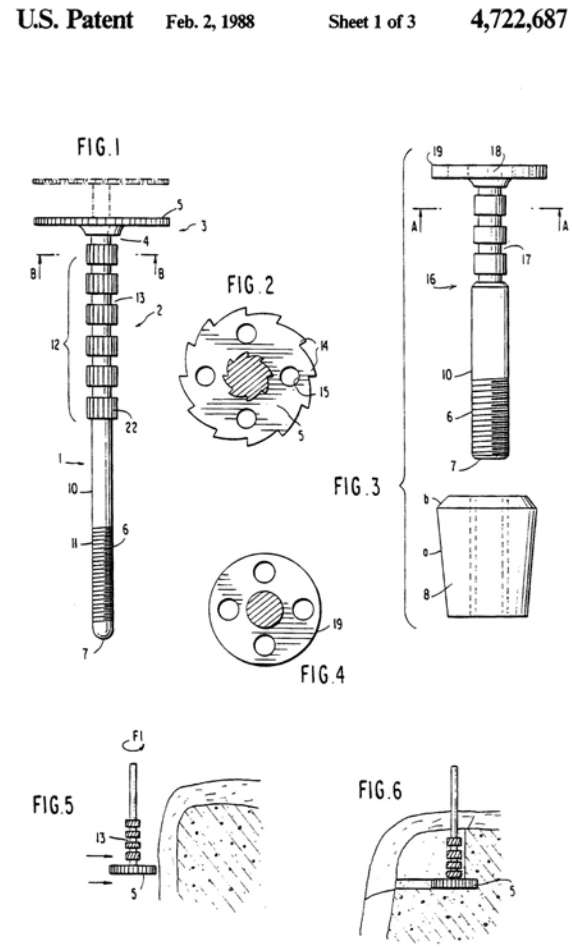


**Fig. 2.3** Drawing from USP 4,722,687

Clunet-Coste, by the way, would initially buy his own implants in Italy to avoid paying his own licence fees. Scortecci, in turn, acquired his Swiss-made implants via Monaco. Zerca discontinued this production line a year after Julliet's death in September 1983. Around the same time, Scortecci entered the market with his cutters and rotationally symmetrical designs named "Diskimplant®". It appears that these developments held great appeal for Clunet-Coste himself because he allowed Scortecci to continue producing and marketing his products without a licence (F.P. Spahn, personal communication, 2001). Anyway, taking out patents on manufacturing processes only in specific European countries is no longer meaningful these days. As a matter of fact, patents on manufacturing techniques are likely to become pointless even if confined to Europe in this era of increasingly global markets and cheap manufacturing sites in the countries of the former East Block.

Three further patents taken out by Scortecci in the USA (1987, 1988) and in Europe (1985) added another chapter to the history of disk implantology.

In his U.S. patent, Scortecci described an implant that served as its own insertion tool. The patent also covers some aspects of the lateral insertion process.

The idea was to design an implant surface that included cutter flutes and to remove the turbine after the bone concavity had been cut, thereby leaving the implant well anchored inside the bone. The turbines available then and today have a chuck diameter of 1.6 mm, which was a limiting factor for the diameter of the implant shaft (i.e. the threaded pin). Consequently, this design routinely led to implant fractures. The system as described in the patent has never been widely marketed.

Figure 2.4 illustrates the lateral insertion path; Scortecci envisioned a system in which the size and shape of the implant bed did not necessarily coincide with the implant design.

Item 8 in Fig. 2.5 shows that the osteotomy path was longer than the implant. This approach presupposes that the cortical bone structure in the mandible is adequately wide. It is necessary to remember that functional alterations associated with the restorative treatment or hormonal changes may lead to massive endosteal resorption. If so, the chances are that the implant will recede in lingual or vestibular direction into the newly evolving cancellous bone areas. This problem has been eliminated in the asymmetrical implant designs, which are discussed below.

The U.S. patents were granted without problems at the time. The procedure went not so smoothly in Europe, where the patent specification had to be revised. Meanwhile, Scortecci had been collecting experience by using his implant designs in practice, so there was time to amend the original patent claims to reflect this experience by the time the European patent was eventually granted. The U.S. patents, by contrast, were granted almost unmodified.

Despite these developments, the resources that were funnelled into the universities for the teaching of dental implantology were invariably distributed in favour of screw implants. Industry was expecting a faster turnaround in revenues from screw implants and reasoned that the insertion techniques could be explained more readily to dentists than the procedure for blade and disk implants. Also, the risks to the prosthetic work seemed smaller if only those screw implants that were found to be intact after a healing period of 3–6 months could be fitted with a tailor-made superstructure.

In other words, the concept of immediate loading associated with the BOI system entailed the requirement that all inserted implants had to be clinically successful. Since any implant failure automatically leads to loss of the superstructure, there is always a risk of financial consequences

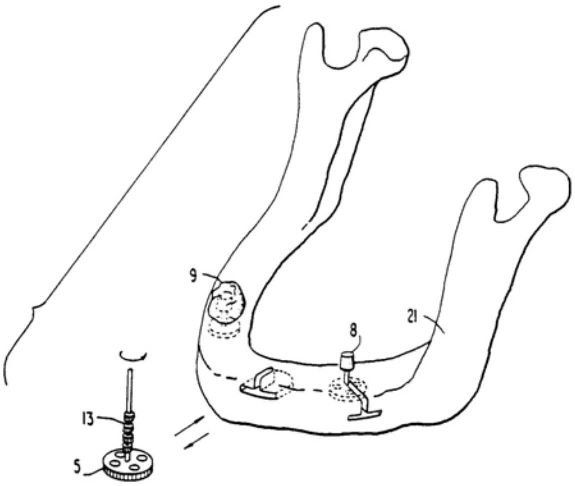


**Fig. 2.4** Drawing from USP 4,722,687 and USP 4,815,974

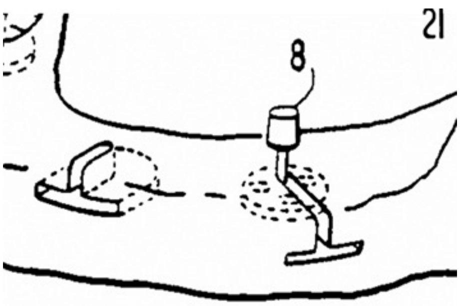


**Fig. 2.5** Enlarged section of Fig. 2.4

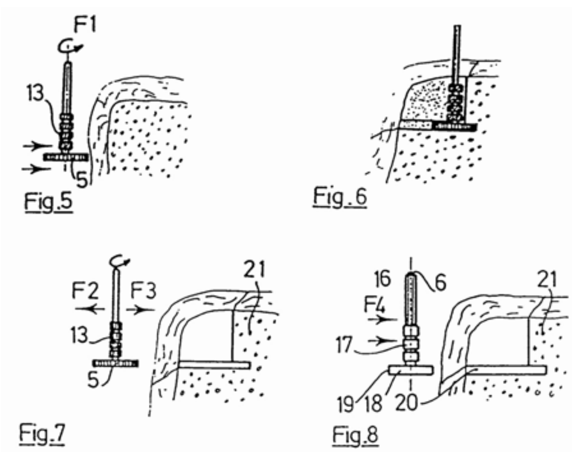


**Fig. 2.6** Another drawing from those productive years shows that Scortecci envisioned the use of small rings along the shaft serving as force-transmitting surfaces and depth indicators. The implant itself also featured rings of this type. The advantage of this configuration was that it gave the surgeon a very accurate idea how long the implant needed to be. On the downside, it involved an additional risk of mucosal and bone irritation in the presence of elastic implant-restoration systems

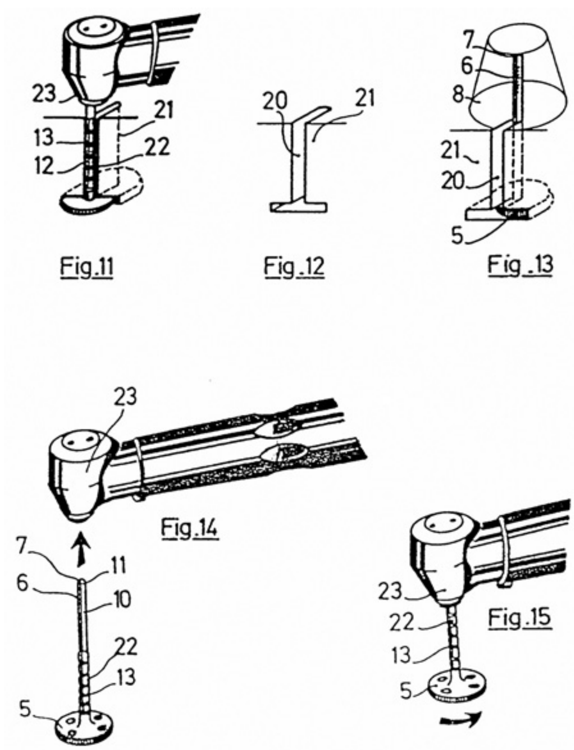


**Fig. 2.7** Drawings from EP 0 241 962 B1. These sketches illustrate in detail the insertion procedure generating the implant bed. The vertical and horizontal dimension of the insertion path were obtained simultaneously by using a specially designed cutter

to the dentist. While BOI went through a phase of inexcusable neglect for these reasons, a flurry of adjuvant procedures for bone augmentation/grafting emerged on the scene. This development may have been a blessing for some – particularly for maxillofacial surgeons – but it has improved neither the actual success nor the theoretical potential of implant treatment.

An essential feature of this design was that implants and tools were separated. Scortecci's patent lawyers deserve considerable respect for the fact that they succeeded, by resourceful phrasing, in incorporating as subclaim 6 the exact opposite of the original idea of the patent application, such that it escaped the reviewers' notice and formed part of the patent granted.

In 1991, Scortecci published a retrospective study on the clinical outcomes of his Diskimplant system (Scortecci et al. 2001). In the years 1979–1989, a total of 5,848 implants had been inserted, 590 of which had to be removed. Most of these implant losses occurred in the period 1980–1984, presumably either because the disk diameters were too small or because the threaded pins were too short. Another factor was that the original disks were not perforated at all; the next generation featured perforations that were still very small. Fractures resulting from the small diameter of the threaded pins (a consequence of adhering to the U.S. patent specification and the 1.6 mm shaft diameter) also contributed to some failures. Notwithstanding, a cumulative success rate of almost 90% over a 10-year period was a remarkable feat, considering that similar figures were also reported for screw and blade implants at the time. With Scortecci's development of standardized cutters for implant beds, lateral implantology ultimately became an option even in the hands of less skilful surgeons. Therefore Scortecci is rightly to be regarded as one of the "founding fathers" of lateral implantology.

In his comprehensive book on dental implantology, published in 2001, Scortecci laid out a large number of treatment options with disk implants. He combined disk implants with "structure" screw implants, mainly for screwed bridges. His multiple implant concept based on 8–14 implants in each arch was associated with huge material requirements and enormous costs. In addition, it turned out that the bone structures would stiffen as a result of this approach. By the same token, today's implants do not feature surface enlargement to avoid irritation of the surrounding bone. As a consequence, individual implants that are embedded in elastic bone segments may turn out to be mobile when bridges are removed. This type of mobility does not have any clinical or radiographic implications. Considering the implant/restoration system as a whole, these mobile implants still constitute a stable basis for the restoration.

Other fellow dentists have also contributed ideas to the development that eventually led to basal osseointegration. The Belgian dentist Robert Streel (1980), for instance, was the first to describe bendable lateral implants. Streel postulated that implant treatment must try to achieve a perfect balance of forces. This demand is not plausible from today's perspective; after all, the bone structure in which the force-transmitting areas are embedded are not uniformly protected against resorption, either.

Areas 5 and 8 in Fig. 2.8 are the bendable lateral stubs.

The fact that disks at the implant base can be used in a completely different manner had been demonstrated by Christensen as early as in 1965. The caudal insertion path of this design has remained somewhat of an obstacle. Dentists are not accustomed to this type of surgical approach.

For the same reason, the transmandibular implant (TMI) design, although offering extremely good results in the treatment of mandibular resorption, has never been too popular among dentists. A

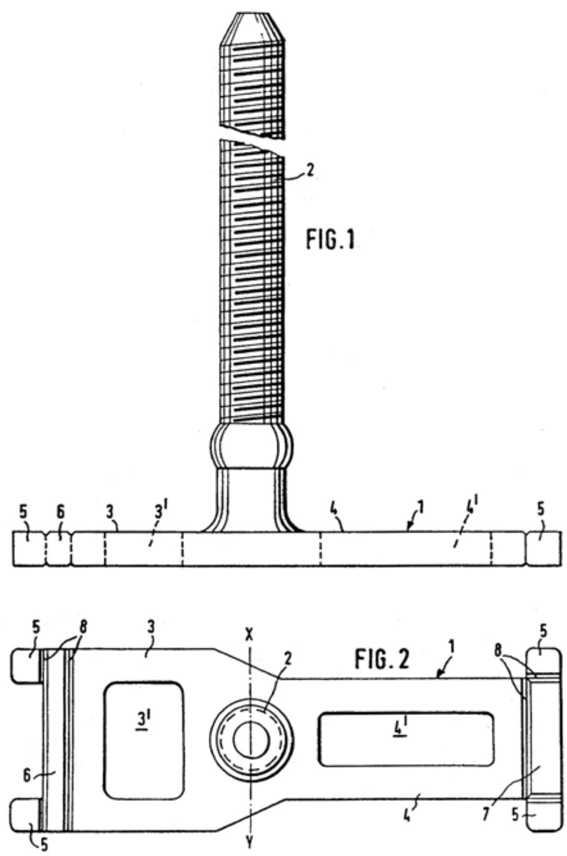


**Fig. 2.8** "Perfectly balanced" disk implant with bendable lateral stubs that are intended to ensure primary stability to lateral forces. In other words, part of the design will be locked up in a subperiosteal position. This concept of basal osseointegration has survived to this day

handful of fellow dentists well versed in surgical techniques have used these implant very successfully for decades. Numerous patients have thankfully recovered their masticatory function in this way.

The TMI system has a lot in common with today's BOI system:

- The implants have no load transmission either near areas where the implant penetrates the mucosa or in the vertical implant portion.
- All load transmission takes place in areas that are safe from infection.
- Load transmission is multicortical.

Another innovative mind influencing the development of dental implants was Albert Kurtis. The design he specified in his patent of 1988 was aimed at anchoring the threaded pin deep inside the bone to endow the implant shaft with resilience and room for flexural manoeuvre while preventing infections from advancing to the load-transmitting implant segments. At that time, features such as round struts for load deflection and round framework transitions to avoid load peaks were remarkable achievements in structural design. The blood supply in the insertion area would probably remain largely intact with this design.

Another name to be mentioned in this context is Alfred Edelmann, whose U.S. patent specification (1978) also included (albeit as a minor point) basal solutions for his implant design.

Kawahara (1989) studied the use of discontinuous surfaces and provided relevant specifications for all types of implants.

In the early 1980s – i.e. in the early phase of "disk implantology" – Scortecci did not pay enough

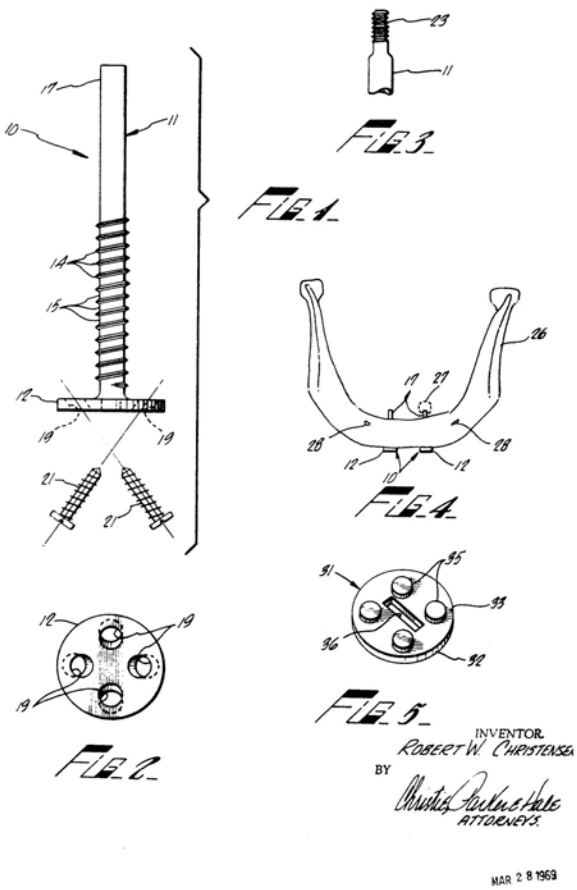


**Fig. 2.9** From USP 3,474,537. Christensen's implant design relied on a caudal insertion path. The disk was not inserted into an enossal position but was covered by caudal bone growth in due course

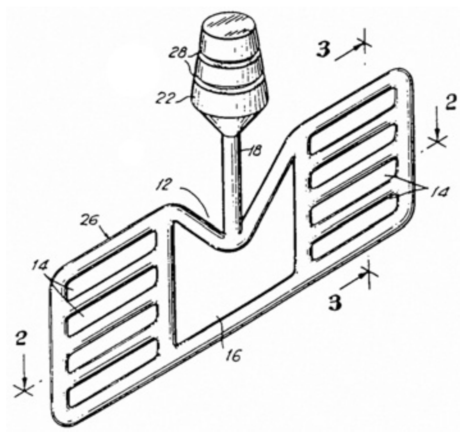

**Fig. 2.10** From USP 4,768,956; skeletized implants in a blade design

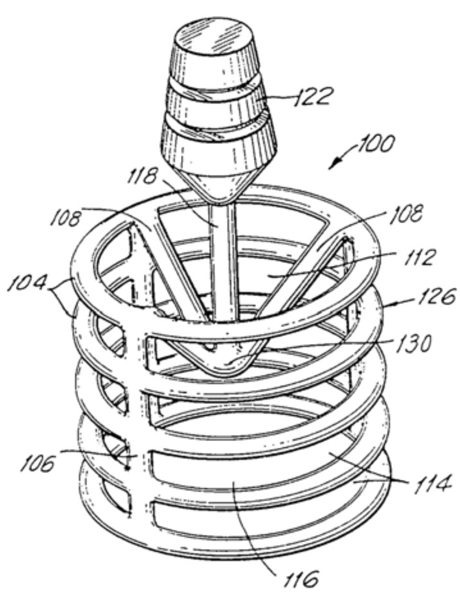

**Fig. 2.11** Implant design of USP 4,768,956 in a basket configuration. Lateral insertion of this implant is prevented by struts 106 and 108

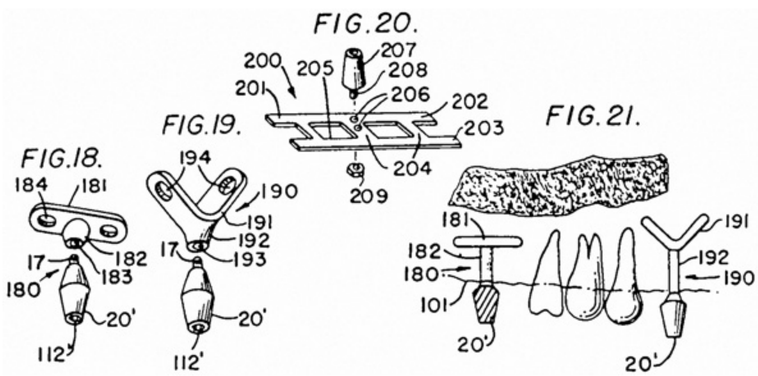


**Fig. 2.12** Edelmann's bendable (adaptable) implants

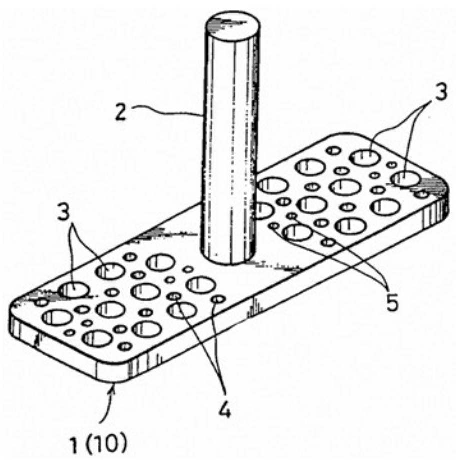


**Fig. 2.13** Implant design with discontinuous surface, from USP 4,964,801

attention to the problem of the compromised blood supply above the implants. Inflammatory osteolysis vertically above the basal plate was a common observation, as the early implant designs were still better suited for use in the alveolar ridge. Complications of this type were caused by insufficient blood supply crestally to the disk, due to the fact that those early disks were not perforated. Based on current knowledge, the type of perforation specified by Kawahara was not up the challenge either and would have failed to ensure an adequate blood supply crestally to the basal plate just as well. Whether his implants were ever manufactured is unknown.

Scortecci's distribution company Victory (Nice, France) marketed two different implant systems. The "ED" series features an external thread (initial thread: M2×0.40; the subsequent version M2×0.25 is still state of the art) and delicate ribs along the shaft as thread markers. Available implant diameters were 5–15 mm. All implants have featured round disks and are available as single-, double-, triple- or even quadruple-disk designs. The distance between individual disks is invariably 3 mm. About 1990, Spahn prevailed on Scortecci to produce "anatomically shaped" multi-disk designs, i.e. implants with multiple disks of different sizes. Two of those new implant types – EDD 12/8 G4 and EDD 15/9 G4 – have since been marketed and used in clinical practice with great success. They have come to be widely used particularly in maxillary restorations. Ideally, they allow quadricortical anchorage in the maxillary sinus, whose bony structure frequently has the shape of an inverted pyramid.

Better utilization of the cortical bone was also what three dentists at ITI had in mind when they presented an implant that included nails for retention. This design by Jürg Schmid, Christof Hämmerle (now a Department Head at the Dental School at Zurich University) and Nikolaus Peter Lang (currently a Department Head at the Dental School at Bern University) (1991) was basically a step in the right direction.

The inventors deserve credit for realizing that implants supported by lateral (cortical) bone would offer advantages in thin bone structures. Straumann AG has never implemented this design. They did not take into consideration the visco-elastic properties of bone and the concept of self-trabeculating as explained in Chapter 9.

The inventors barely missed the bull's eye on yet another occasion. A basal plate with an internally threaded cylinder attached to it was also specified in the German utility model application of 1994. Obviously, the spikes intended to offer anchorage in the bone can only be effective in the initial phase. Later on, they will invite load peaks and local osteolysis.

This design was in effect an "on-plant" rather than an "in-plant". In addition, it was intended to hold a membrane that would stimulate bone growth underneath. Given the scanty blood supply, it is reasonable to assume that a structure of this type would routinely lead to severe infections and eventually to the loss of the entire implant-restoration

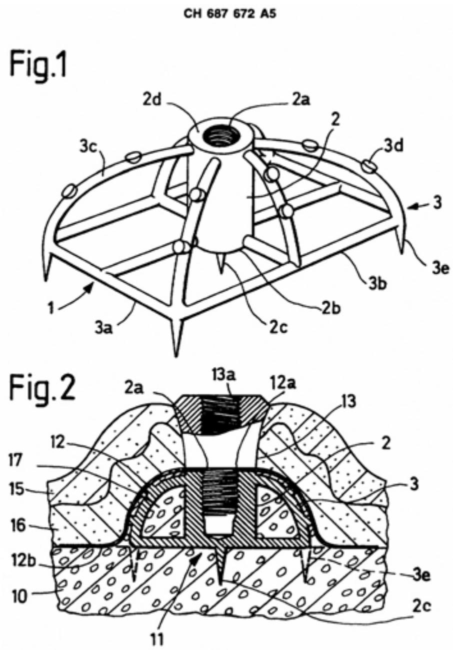


**Fig. 2.14** CH 687 672 A5: The three-dimensional structure in Fig. 2.1 is designed to accept incoming loads without fracturing. The thin struts were hardly capable of handling masticatory loads in an adequate manner

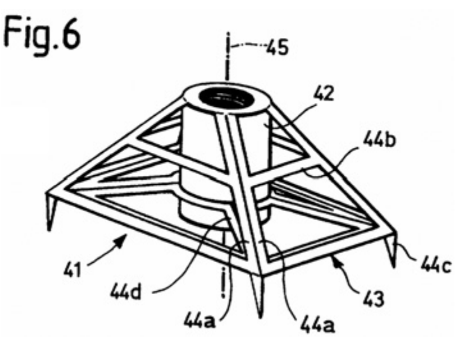


**Fig. 2.15** From the same patent as in Fig. 2.14. Angled struts would presumably turn out to be very inappropriate in clinical practice. This implant design reflects a mechanistic mindset that is very detached from the realities of human biology. An implant of this type would be "extraterritorialized" from the very outset and stands little chance of being successfully integrated

complex. While the latter two developments bear no direct relationship to basal osseointegration, they do illustrate a specific mindset that was prevalent in a specific era. They illustrate how a group of scientifically committed dentists tried to work out solutions in which treatment planning would not be guided by the rules of biology and function but would expect human biology to yield to its own set of rules.

Meanwhile, a good and practical solution was developed almost simultaneously in various dental offices. K.-H. Müller applied for a patent for his double-unit design (1999), which included a threaded pin to be screwed to the basal plate. The principal objective was to provide anchorage for restorations along the maxillary sinus. Müller's idea to place the basal plate inside the maxillary sinus but below the Schneiderian membrane was brilliant and farsighted. Using this concept, the residual bone volume under the sinus will be protected against infection and will even be preserved if the implant is lost. The inventor stated that he had been led by theoretical considerations without ever using those implants himself. Some aspects of this new concept had been used previously in the clinical work with single-unit BOI implants.

About the same time, Spahn applied for a patent on a multi-unit implant system featuring screw connections and a multi-threaded pin (1999).

Ihde and Spahn had laid the foundation for basal osseointegration even before that time, by applying for a patent on the first elastic implant design, thus turning away in theory and practice from the rather mechanistic theory of crestal implants and rigid bone-implant-prosthetics systems.

The basal plates were configured to match the anatomical shape of the jawbone, and the crestal plate was placed in a more resilient position than the basal plate. By virtually eliminating the risk of crestal osteolysis in the maxilla, this development can be regarded as a milestone in the history of BOI. At the same time, load transmission in the area of the crestal plate was confined to the palatal bone, which apparently was much better suited for this task in terms of structure, resorption tendency and blood supply than the vestibular bone.

By 1998, Spahn and Ihde had not definitively arrived at the conclusion that load transmission in the area of the threaded pin was altogether unnecessary. Therefore, the early implants of these series would still feature the rib-style surface enlargement described by Clunet-Coste. Those designs, in effect, marked the transition from crestal to genuinely basal implants.

The feature of a surface-enlarged shaft was eliminated only 1 year later when the Swiss patent specification CH 690 416 A5 was submitted as a corollary to EP 99 250 289.8.

More recently, further improvements have been added to the macro- and micro-design of the load-transmitting areas and to the transition zones towards the non-load-transmitting framework areas.

**Conclusion.** The idea of basal, wide-area support for implants was taken up by many developers at some point. In many of the patents and patent applications quoted here, the resolution of situations in which insufficient vertical bone volume was available was what gave rise to the various ideas. Other developers were more interested in utilizing the harder cortical bone tissue also for immediate loading procedures. Only Julliet (1972), Scortecci (1985) and Ihde (from 1998) ever turned their ideas into successfully marketable and clinically practical products.

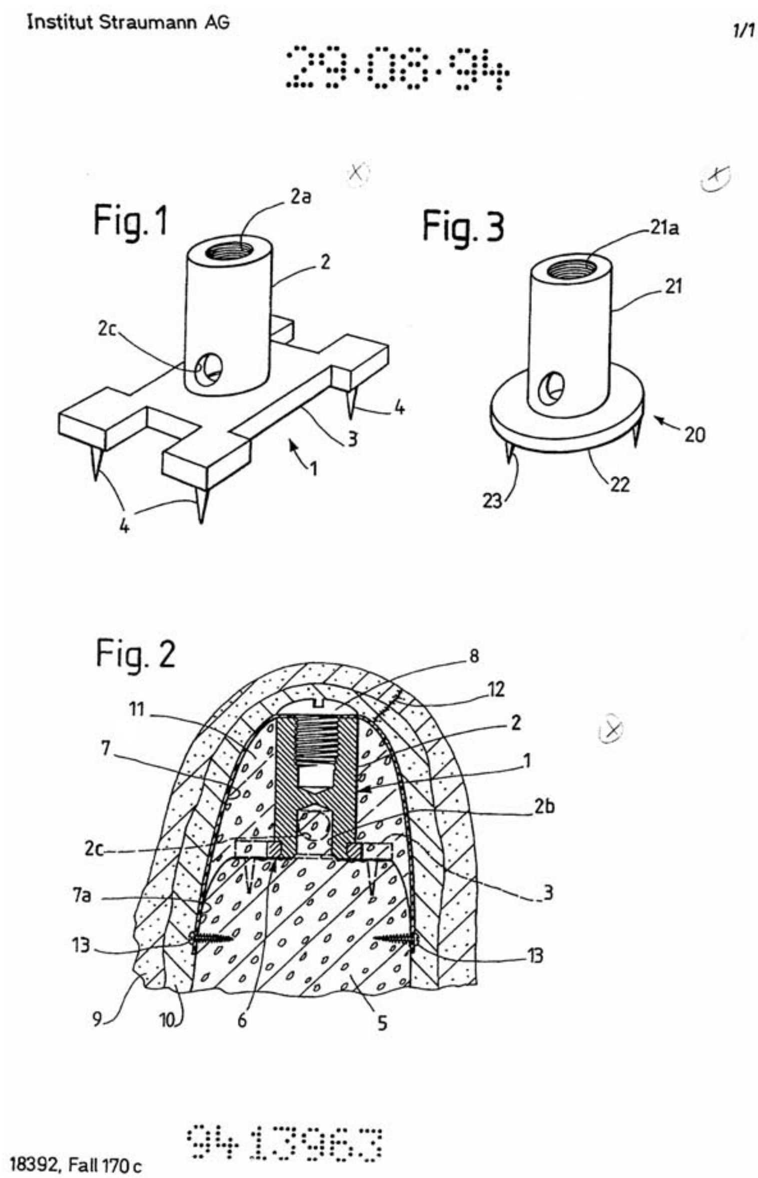


**Fig. 2.16** Implant design featuring an internally threaded cylinder, a spiked basal plate and a membrane intended to stimulate bone growth

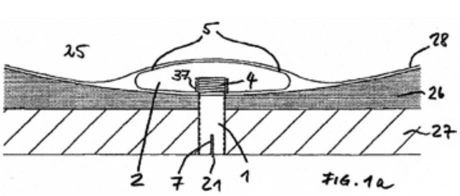


**Fig. 2.17** Müller's double-unit implant was anchored inside the maxillary sinus and featured several insertion points for the threaded pin. The more recent Disktrack system was modelled after this design. There were no legal obstacles to this development because Müller had never followed up on his patent application

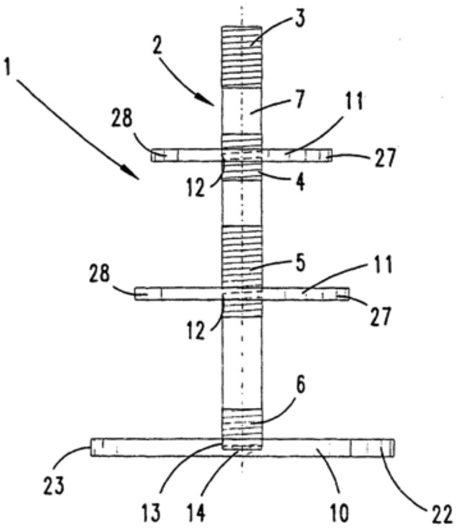


**Fig. 2.18** The threaded pin comprises several "storeys" to which load-transmitting plates of different shapes can be attached. In contrast to the later development of distractor implants, Spahn's design had always relied on pre-cut insertion pathways matching the disk-to-disk distance. Distractor implants are inserted by separating bone compartments for rearrangement at a later time, which is not the case with Spahn's design

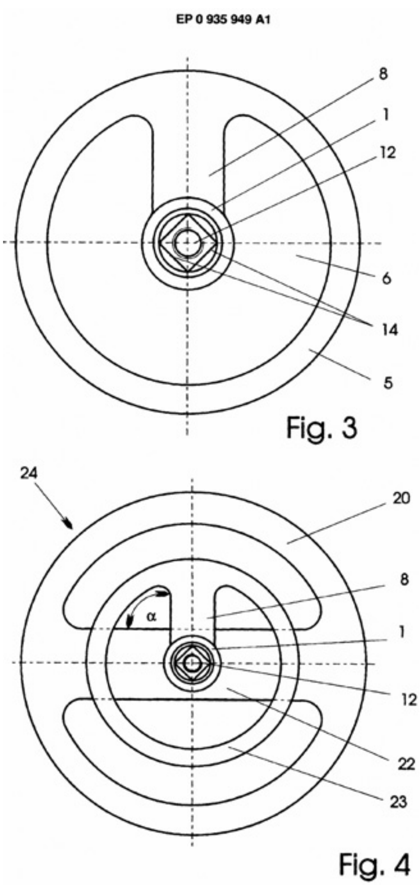


**Fig. 2.19** Ihde and Spahn, in a collaborative effort, developed implants that behaved elastically inside the bone, allowing resilience of the threaded pin. In this way, the dogma that all enossal implant segments needed to be "osseointegrated" in a static way was broken. The construction of these implants enabled the transmission of unequal parts of the load to both basal plates. The basal plate was designed to be more rigid than the crestal plate. Hence a larger amount of the chewing force was transmitted through the lower plate while the crestal plate provides initial stabilization. It is necessary to remember that it is invariably the basal portion of the implant body that will transmit force in all implants in the long term. If dentists are shown FEM analyses or photoelastic stress images of implants embedded in Plexiglass in "scientific" studies, they will always show local stress peaks in the collar region of the implant. But these studies or images do not reflect the true situation. Unlike the Plexiglass model, live bone can avoid these stress peaks. There are several mechanisms at work to achieve this, such as changes in the relative level of mineralization by redistributing 0-areas and 1-areas. If the stress peak were actually located in the collar region, this would result in massive mineralization, and we would never see the crater-style bone collapse characteristic of crestal implants