Treatment Planning

S. Ihde and T. Maier

Thanks to the technique of basal osseointegration, we are today in a position to treat 95% of completely or partially edentulous patients with fixed restorations. This goal can only be achieved if a number of rules are observed with regard to where the implants should be placed and when and how they should be combined with residual teeth. Most importantly, the implantologist must understand the functional requirements of the treatment and perform occlusal adjustments in a timely manner.

There are currently two distinct philosophies of how BOI implants should be applied. While they are both clinically successful, they do have their specific advantages and disadvantages. The treatment philosophy advocated by Ihde, Haas and Spahn relies on only four implants per jaw, inserted at strategic positions. This approach does not impede flexion of the bone structures between the implants. In this way, a bone-implant restoration with adapted flexion is created.

The other treatment philosophy, advocated by Scortecci, Heuckmann and Maier, aims to create a rigid implant-restoration system by inserting a maximum number of implants. As these systems are more rigid than the bone itself, the force-transmitting surfaces cannot become seamlessly integrated in their entirety at a high degree of mineralization.

7.1 Scope of Therapy

Strategic implant positioning is the least traumatic approach conceivable, and it optimally preserves the flexural properties of the jaw. Its main shortcoming is that a reliable configuration of forces can only be obtained if the baseline situation is correctly analysed and if the outcome is closely monitored over the following 12–24 months, until the phase of bone healing, remineralization and functional optimization is completed.

Implantologists commonly see patients who are aware that they have a problem with a partial denture and who want treatment to be confined to that specific area. In this situation, it will first be necessary to assess whether such local treatment is a good idea. The unilateral tooth loss may, for instance, have been caused by excessive loading related to an unbalanced functional pattern. However, unilateral chewing will not resolve spontaneously if most of the other masticatory surfaces in the mandible are malpositioned or if an unsymmetrical AFMP angle is present because the residual cusps generate an unfavourable guidance. There was a time when we were inclined to oblige with requests to perform such local treatment. Today our preferred approach is to readjust the masticatory function at large and to decline treatment if an understanding is not reached. Readjustment requires early implant procedures for its fixed foundation.

Treatment decisions in favour of strategically placed implants to support a complete fixed bridge can be made more readily if the following conditions are met:

- The skeletal midlines of the maxilla and mandible coincide (clinical examination and/or OPG).
- The clinically observed AFMP angles are similar on tooth-guided lateral movement to the left and right.
- The path covered during lateral movements is about the same in both directions.
- The mouth opens with a straight movement.

If there are any functional obstacles to achieving a balanced situation, the implantologist must consider inserting a greater number of implants (using multi-disk designs), thus abandoning the concept of strategic positioning.

Chapter 10 will include a detailed discussion of functional aspects and their impact on therapy and bone maintenance.

7.2 Number of Implants for Complete Bridges

Minimizing the number of implants by strategic positioning is a very successful approach, but maximizing the number of implants has its advantages too. A detailed discussion of the pros and cons follows.

7.2.1 Maxillary Restorations

The positions of the canines and second molars are used as strategic implant locations both in the mandible and in the maxilla. In our experience, if implants of adequate size and stability can be inserted at these sites, there will usually be no need for any additional implants. In fact, only one additional implant placed in the nasal spine area may create a hypomochlion situation, making the prosthetic structure tilt around that point. Bridges that are supported by implants only always carry a risk of asymmetrical intrusion if a different number of implants or load-transmitting disks were inserted on both sides of the jaw. The canine position usually offers enough space to insert a single-disk implant with a high G value and a disk diameter of at least 9 mm. Alternatively, triple-disk implants with a diameter of 7 mm, or with a larger diameter at the basal disk, are an option as well. If a substantial bone volume is available, double-disk implants with a maximum disk-to-disk interval can be used. These designs are today available with a basal disk diameter of 12, 14 or 15 mm.

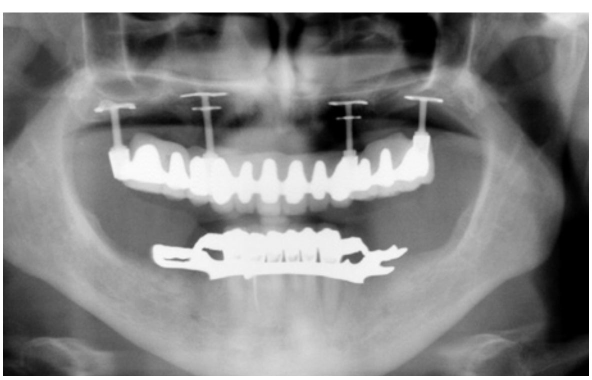
EDAS implants with a basal surface area of 9×12, 9×14 or 10×14 mm can normally be used for the distal abutment at the position of the second molar. Additional use of a pterygoid screw can enhance the stability of the implant-restoration system.

If adequate support for the bridge cannot be created at the canine positions, the dentist should consider establishing an implant-restoration system based on a large number of implants (multi-implant concept). This technique has been used for many years by implantologists like Linkow, Grafelmann, Bauer, Brinkmann, Heinrich or Scortecci. It also involves the use of numerous different implant designs (diameters, lengths) and requires comprehensive training in implantology and a well assorted stock of implants in the office. In addition, it requires excellent three-dimensional thinking. Multi-implant treatments are expensive and time-consuming, but they offer a very good prognosis.

The degree of resorption and bone quality varies widely in the maxilla. In situations where bone conditions have remained stable over an extended period of time, it is sometimes possible to identify function-related patterns. Usually, the bone structure is narrow but relatively high in the anterior segment, flat in the subantral portion of the posterior segment, and once again rather voluminous as well as soft in the tuberosity area. The muscle attachment areas of the lateral pterygoid muscle are usually well mineralized. These differences require the use of a wide range of implant types to take advantage of the native multicortical bone structures while avoiding any more extensive grafting or augmentation procedures. Anyway, it would not be possible to obtain an adequate primary stability of the implant based on transplanted or augmented bone, since these structures cannot possibly mineralize to the required extent in such a short time. The compensation that surface effects can provide for missing macrotrajectories is very limited. Note also that surgically treated areas remain undermineralized for a long time.

We suspect that all currently known surface types are rather similar in quality, with the exception of three-dimensional matrix surfaces, which allow perfusion of the bone from two sides (Osseopore implants). After all, the main disadvantage of enossal surfaces is the impaired blood supply and drainage.

According to Misch and Judy, the anterior maxilla should be equipped with as many primarily stable implants as possible to compensate for the initial weakness of the distal segments. It is irrelevant which implant designs are combined to achieve the goal. What matters is that the bone volume is ingeniously and adequately utilized. Any residual teeth in the anterior segment can be helpful as well.



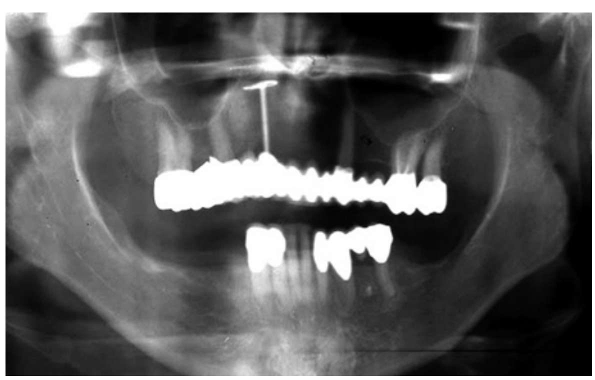


Fig. 7.1. a Maxillary restoration supported by strategically positioned abutments. **b** In many cases, all it takes to obtain strategic abutments for durable maxillary restorations is to combine a single BOI implant with residual natural teeth

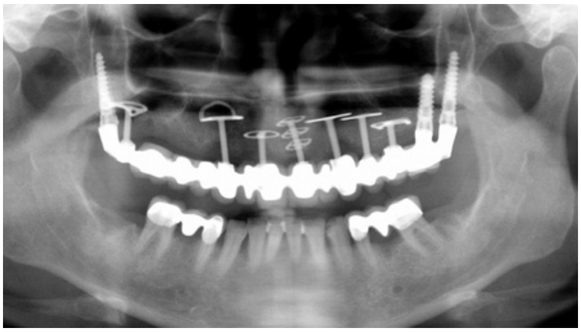


Fig. 7.2. Maxillary restoration supported by multiple implants. The distal abutments consist of tuberosity and pterygoid screws, while BOI implants were used in the anterior segment in accordance with the available bone width. The BOI implant at 13 was vestibularly folded and adapted to the vestibular surface of the maxilla

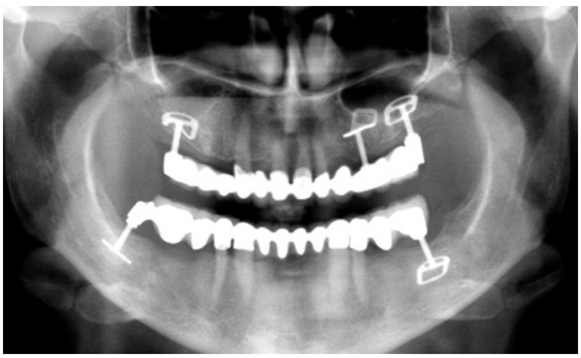


Fig. 7.3. Canines can offer very good support. They can be used alone or in combination with the first premolar

In situations of advanced resorption, it is no longer possible to differentiate between basal and crestal implantation. The important part is to utilize the cortical bone.

7.2.2 Mandibular Restorations

Since the mandible may be subject to heavy torsion, a multi-implant strategy would overly reduce the elasticity of that bone. For this reason, we generally use four to six implants, with one distal implant on each side only. Stable canines can be used instead of an implant.

Today we tend to use no BOI implants with more than one disk in the distal mandible and prefer to put no implants at the premolar positions to ensure that the elasticity of the mandible is not overly reduced and that no high point is created in the middle of the horizontal part of this bone. Triple- and double-disk BOI implants can be used to good effect along the anterior block of the mandible.

In the maxilla, BOI implants may be combined with natural abutments in virtually any combination, as long as the teeth are stable enough to offer long-term resistance to the forces acting on it. When considering a tooth as part of a larger bridge, it should be considered that overall masticatory forces will increase.

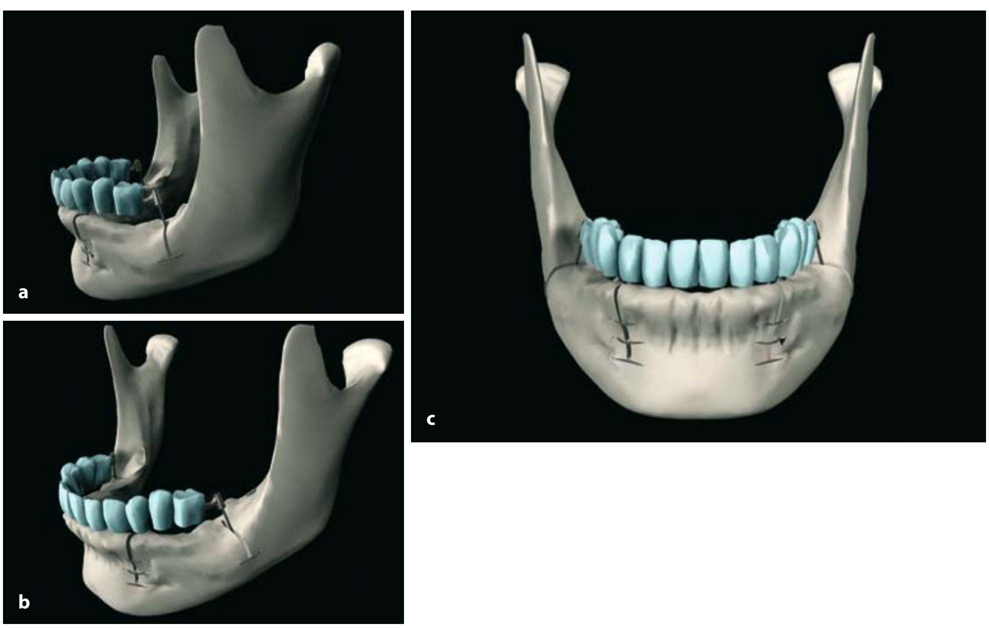


Fig. 7.4a–c. These schematic drawings illustrate the correct implant positions for strategic implant placement in the mandible

7.3 Which Jaw Should be Restored First?

Concerning the issue which jaw should be restored first, we have developed the following approach in our clinic: if therapeutic modifications are needed in both jaws, the mandible should be treated first if possible. There are several reasons:

- Complete dentures are not retained nearly as well in the mandible as in the maxilla. Therefore, the need to provide relief is greater in the mandible.
- In many cases, additional implant treatment in the maxilla turns out to be redundant once a fixed restoration has been inserted in the mandible.
- The morphological changes in the mandible are often substantial, particularly in the wake of adjustments performed to re-establish a normal masticatory pattern. Simultaneous placement of implants in the maxilla and mandible carries a high risk of overloading the newly inserted implants in the maxilla. Relative elevation of the distal implants is especially liable to inflict damage to maxilla. Conditions are more favourable once the functional adaptation after implant placement in the mandible have been largely completed.

Similar results were reported by Lindquist and Carlsson (1982), who observed that the ability to eat eight out of ten types of foods that the patients had previously been unable to eat was restored after inserting a mandibular restoration supported by enossal implants. Chewing function was significantly improved once these restorations were in place. In patients on a limited budget, a cost-benefit analysis will therefore definitely argue in favour of providing an implant-based solution in the mandible rather than the maxilla. This strategy will be effective in the majority of patients and will often render additional treatment of the maxilla redundant. According to Lindquist and Carlsson, implant treatment of the maxilla is only necessary in specific cases. We feel that this view needs to be put into perspective, as considerable progress has been made with implant treatment in the maxilla since 1982. With today's BOI technology, implant-supported fixed restorations have become just as affordable, successful and simple to realize in the maxilla as they have been in the mandible all along.

Treating the mandible first makes sense from a functional viewpoint as well. Tallgren et al. (1986) demonstrated that the changes in masticatory function brought about by inserting immediate dentures in the mandible can be reduced if a fixed dentition is at least partially present in the mandible. This conclusion is quite plausible, considering that better muscle orientation is achieved during chewing if reliably positioned teeth are present in at least one jaw.

If a complete denture is present in the maxilla, the necessary elevation of the occlusal plane towards Camper's plane can be performed more readily than in the presence of a fixed restoration or of elongated natural teeth. In spite of that, the occlusal plane should always be equalized if necessary. Trying to save money on this aspect of treatment will be counterproductive in the long term.

One also has to keep in mind the fact that the teeth in the mandible often resist imbalanced situations better than the teeth in the maxilla. If in the maxilla large bridges are present, this will sometimes lead to a situation where a patient faces a complete breakdown of the maxillary restoration and dentition with the reason for the brakdown being located in the stronger, but unbalanced and/or unfavourably designed prosthetics in the lower jaw. We strongly recommend in these cases always to treat the lower jaw first or simultaneously, because it is dangerous to rely on the patient's willingness really to treat the mandible after the problems in the (aesthetically to him/her more important) upper jaw. We have seen sad cases where the patients forgot about the agreement about treatment in the mandible, vanished from the scene (even missing regular check-ups in order not to be reminded about the agreement), and returned later with problems again in the upper jaw.

7.4 When Should the Implants be Loaded?

Obviously, there is no way for implants to remain completely "non-loaded" once they are located within the bone. The appropriate point of time at which all or part of the chewing force should be transmitted through all or some of the BOI implants onto the cortical bone will depend on the conditions present during surgery, the number of implants inserted, and the general circumstances under which mastication takes place. Since the cranial bone is permanently in a state of torsion, there can be no such thing as a "non-loaded" state of implants. We therefore maintain that it is more sensible to define the type and direction of loading via a prosthetic superstructure than to leave the bone without this well-dosed stimulus.

Part of this rationale is to insert the superstructure while excellent primary stability is present. Following this logic, prosthetic loading should take place within the 8–12 days (the sooner, the better). Due care must be exercised in deciding on this strategy, which may be contraindicated in specific cases (i.e. in surgically pre-treated areas). The other alternative would be to load the implants after 6–8 weeks when the phase of bone healing and bone repair has been completed. The implantologist may want to select a different time if numerous abutments are present, provided that the superstructure can then be inserted in a tension-free manner. Such re-scheduling is less advisable in the maxilla than in the mandible with its considerable macrotrajectorial stresses.

Both jaws undergo extensive bone remodelling. If a large number of load-transmitting disks have been inserted, it is unlikely that individual implants are loaded to the point of creating deleterious osteolytic processes. On the downside, little bone will remain for a second treatment attempt if implants become unstable because of other factors.

Essentially, we always attempt to insert as many implants and load-transmitting surfaces in the surgical phase of treatment as are necessary to realize immediate loading. In first implantation procedures, the goal of immediate loading can be achieved almost invariably. A temporary restoration is inserted in the maxilla for 2–12 months, while the mandible can usually be treated with a definitive restoration right away. Temporary restorations may need to be replaced or adjusted inside or outside the mouth several times, particularly in the maxilla, as functional and morphological alterations are developing over the course of treatment and/or extensive chewing-related adjustments have to be performed. On occasion, it may be necessary to compensate for spontaneous repositioning of the TMJs. Such repositioning may only occur after weeks or indeed months and may proceed in a stepwise fashion, reflecting the step-by-step release of spastic contractions of the lateral pterygoid muscle. In those cases, the masticatory surfaces must be redesigned several times, also taking into consideration that the steepness of the cusps must fit the age of the patient. Any delays in readjustment may trigger a unilateral or anterior chewing pattern.

7.5 General Biomechanical Considerations in Treatment Planning

BOI implants are designed to replace natural teeth and assume their function of transmitting the incoming masticatory loads into the bone. They consist of one or several load-transmitting disks (also referred to as basal plates or rings), a threaded pin not designed for load transmission, and web bars connecting the disk(s) to the threaded pin. The disks are available in different shapes aimed at optimally adapting the integrated implants to different bone configurations. Correct choice of the dimensions of the BOI implant is required because BOI implants, unlike screw designs, always utilize the available native bone structure to anchor the implant-restoration systems. The bone available at the beginning of the therapy is considered to be the best bone of the patient, because it is assumed to be in the areas of main trajectories under functional conditions.

Cortically anchored basal plates are an integral component of BOI implants designed to guide the masticatory forces into the enossal space. Depending on the indication, one or several disks per implant may be required, along with threaded pins that are relatively rigid or elastic. The enossal surfaces of the implant may be either roughened or smooth, depending on the task they are designed to fulfil both in the early treatment phase and in the long term.

In our experience, disks with a diameter of less than 9 mm will always constitute relatively rigid points of load transmission. Strictly speaking, these designs do not allow implant-restoration systems that truly conform to the principle of basal osseointegration. At least, the elasticity of these systems will be considerably reduced. This clinically undesirable lack of elasticity is aggravated by short threaded pins and disks that are small in diameter but thick.

In addition, the mechanical properties of the implant material are an important factor as well. BOI implants are usually made of Grade 1 (ASTM F 67), Grade 2 or Grade 3 titanium as per that ASTM standard. Some designs are also available as an extremely strong titanium-molybdenum alloy (Ti15Mo). This alloy combines the elasticity of Grade 1 titanium with a level of strength that can otherwise only be attained with Grade 4 titanium. Long-term observations with this new material are not yet available. We currently use this material in structures that have to resist great lever forces. This is frequently the case when massive skeletal discrepancies of maxillary micrognathia or mandibular prognathia have to be overcome.

The purpose of this book is to describe how implant-restoration systems can be integrated more or less isoelastically into the viscoelastic environment of the human jaw. Bone quality as defined by Misch (I–IV) only describes the present condition of the bone, which is obviously poor in edentulous situations as the bone is not trained. Therefore, this classification is largely irrelevant for anatomists and BOI implantologists alike. Measuring Hounsfield units is, in effect, totally useless if we consider that the measured parameters will change instantly once implants have been inserted.

The only interesting aspect is how the bone mechanisms responsible for recognizing, scanning, rejecting or enclosing the implant can be optimally utilized. These mechanisms are more likely to behave according to plan if an intact blood supply is available and if osteogenic stem cells are present in large numbers even at the outset of implant treatment.

There are also situations in which more rigid designs (e.g. triple-disk implants of the "EDDD" type) are an appropriate choice. They can be used in conjunction with other BOI or, indeed, crestal implants to support more rigid implant-restoration complexes, or they can be used as single-tooth implants to replace anterior teeth or premolars in the maxilla or mandible. Bar attachments can be used to good effect on triple-disk implants as well.

Although the concept of (iso)elastic anchorage of dental implants reappears several times in the history of our profession (Breme et al. 1993), the concept was fully realized only on a few occasions. (Intramobile elements were developed and introduced by IMZ in the early days of modern crestal implantology, based on the realization that the human body was a viscoelastic system and should not be treated with rigid implants connected by rigid splinting. Other manufacturers did not follow suit, however, and today the concept is regarded as obsolete. We are told that the market "did not accept" these designs and that they are old-fashioned. More probably, other products were supported by heavier advertising and came in ahead, despite the fact that the IMZ concept as such was biomechanically flawless.)

With crestal implants, mobile incorporation of the implant body is, after all, tantamount to fibro-osseointegration, which will quickly give rise to implant loss once the fibrous area gets infected. This problem does not exist with BOI implants.

Crestal implantologists infer from this that the jawbone will grow towards implants for which primary stability has been achieved "voluntarily" and "deliberately", as it were, to prepare the ground for functional load transmission. As will be shown further below, a substantially greater incentive for bone remodelling comes from stimulation of neighbouring osteons when force transmitting trajectories are disrupted in the process of preparing the implant bed. This mechanism has been well known also in orthopaedic surgery. The implant itself mediates stimuli only to a very small extent in the direct contact area.

The forces acting on the various bones of the skull vary widely in different cranial areas. These bones are therefore elastic and show very different degrees of mineralization depending on their exact location. These observations are most apparent in the anterior mandible. Areas characterized by lower mineralization and higher elasticity will respond to flexural forces by more extensive deformation. Introducing large (long) implant bodies in areas of this type can give rise to any one of the following scenarios:

- The elasticity of the surrounding bone may decrease to match the elasticity of the implant. In that case, other zones of high elasticity will form in that jaw instead.
- The high elasticity may remain intact, but only a small percentage of the enossal surface becomes osseointegrated.
- The high elasticity may remain intact, and a high percentage of the enossal surface becomes osseointegrated, but the bone is undermineralized, so that the various bone layers are freely mobile.

The term "extraterritorialization" of the implants has been proposed because osseointegration was regarded as a delimiting reaction – a process of "cystification", as it were. An implant thus becomes extraterritorialized as cortical bone forms in the interface area, ultimately reducing the blood supply and exterminating any osteocytes near the implant. This reaction is also due to a disrupted oxygen and substrate supply, which eventually causes the osteocytes near the implant to become pycnotic and thus threatened by extinction.

In crestal implantology, it has been postulated that the surface available for osseointegration should be as large as possible (DGZMK, DGI, 2001) to optimize the long-term survival of the implant (Brandt 1996). This demand led to the introduction of long implants, followed by large-diameter implants. These developments ignored, however, that the mucosal penetration point of large-diameter implants is considerably larger, thus offering more space for infection. The prognosis of short implants with roughened surfaces is seriously marred by the fact that bacterial loads rise exponentially with increasing implant diameters (Knaus 2000; Müller-Herzog and Lindorf 1996). The intraosseous blood supply is presumably greatly reduced, which may even promote the development of sarcomas down the road. Some of the postulates of crestal implantology are indeed questionable. As a case in point, the prognosis of implants covered with a porous coating allowing perfusion until deep under the surface (Osseopore) becomes poorer with increasing implant lengths because the perfusion system loses its functionality in longer designs.

Longer implants placed in areas of flexion are bound to transverse various enossal layers that will change their relative positions during normal chewing function. These movements are more apparent in the mandible, but they are significant in the maxilla as well. In contrast to the specially prepared skeletized skulls used for anatomical studies, live cranial bones are characterized by relative mobility and high hydrostatic pressures. In addition, they are affected by the rhythmical movements of the craniosacral, respiratory and masticatory systems. Notably by the active movements of mastication and facial expression, the bones are constantly kept in a state of mutual flux and intrabony torsion. Note that the intraosteonal flow of nutrients is enhanced by bone torsion.

The successful outcomes of slightly conical non-threaded implants with a spherical surface (Osseopore) demonstrate that the same degree of anchorage can also be obtained with very short designs. These implants stimulate mineralization in a radiographically demonstrable manner and are capable, according to their users, of supporting prosthetic restorations while involving rather distorted crown-implant ratios. Obviously, these implants cannot be splinted since the tensions developing through the prosthetic structure would eventually result in bone avulsion after all. The first point to consider with these implants is that they should be inserted over their entire length into a bone layer of uniform behaviour. As a result, the level of functional movements inside the bony implant bed will be relatively low. In other words, these implants will remain unaffected by any local or comprehensive movements of the cranial bones – provided, of course, that they are not used to support large-span bridges. The second point to consider is the ingenious surface structure of these implants, which initially prevents the bone from growing too deeply under the surface. The empty space just below the surface represents a confluent system of canals that enables nutrients to be supplied by way of microcirculation very much as they are supplied naturally through osteons. In other words, the surface on which the bone layer will be forming bears greater resemblance to a three-dimensional microtitre plate than to a dead implant surface. This example once again demonstrates that even minute contact surfaces will ultimately be sufficient to adequately guide masticatory loads into the bone. As a prerequisite, however, the surface contact must be located in an area that is well supplied with nutrients. With cortically anchored BOI implants, these nutrients may be derived from the periosteum or from the interior of the jaw bone. With crestal implants, it is sometimes possible to achieve this goal through ingeniously structured surfaces and carefully selected implant sites. From the points that have just been discussed, it becomes clear why the minimum lengths and surfaces that have been "scientifically" postulated for crestal implants only apply to specific implant designs. In other words, they only apply to implants with surface characteristics that are conventional or do not lend themselves to biological integration because they cannot be perfused well in one way or another.

At this point, a brief discussion of what has come to be known as "root-form implants" may be useful. This term suggests that these designs imitate nature, as it were, by being configured and behaving like natural teeth. This view ignores, however, that those implants are totally immobile inside the jaw. In other words, they are virtually in a state of ankylosis. Ankylosis of natural teeth is undisputedly a pathological state requiring treatment unless the tooth only becomes ankylosed in its clinical desirable end position. Crestal implantologists try desperately to establish this pathological state as a treatment objective. The nonsensical term of "functional ankylosis" used in this connection is actually a perversion of the underlying concept. Osseointegration along the vertical dimension is, of course, an inherent requirement for crestal implants since they lack any horizontal components. Therefore, jaw area in which these implants are located is reduced. The longer the implant, the greater the loss of elasticity. A designation like "root-form" implants is purely formal in meaning and cannot change the fact that these designs lack essential characteristics of natural roots such as elastic suspension or functionally supported adaptation of perfusion. BOI implants, by contrast, are elastically suspended between cortical bone structures. In this way, the viscoelasticity and flexibility of the jaw area are adequately preserved. In addition, the connective tissue along the vertical implant axis does not interfere with flow perfusion. Apparently there is a need for this perfusion to be intact, which is why osseointegration takes much longer on these implant surfaces than on the basal disk segments.

The first generation of disk implants by Julliet allowed virtually no elasticity whatsoever. Although they were made from elastic Grade 1 titanium, they were just too thick to afford the required degree of isoelasticity. Even the Diskimplant designs made by Scortecci from Grade 2 titanium were (and continue to be) only suitable for BOI-based implant-restoration systems if the disk diameter was adequate. The reason is obvious: on the one hand, small designs are not capable of reaching the cortical bone structures in all situations; on the other hand, higher grades of pure titanium are not capable of generating the state of near isoelasticity required to obtain adequate osseointegration of the load-transmitting surfaces. Having said that, implant losses are extremely rare precisely with 7G8 ED, 7G5 EDD or 7G7 EDDD designs, due to the fact that they are usually inserted in highly mineralized bone areas where elasticity is not a top priority consideration. Scortecci demonstrated in his book that rigid implant-restoration complexes could be established very successfully by inserting a large number of rigidly designed implants in combination with screw implants.

Today's Diskos-type implants offer a balanced combination of shape, thickness and size. Their development was based on the input of experienced users, giving rise to a design that is optimized for the expected functional loads and the mobility of the human skull while ensuring that adequate osseointegration of the basal plates is achieved at all times.

7.6 Cementing Versus Screwing

There is no simple answer to the question whether superstructures should be cemented or screwed to implants. A preferred approach of crestal implantology (particularly in the maxilla) is to screw a bar attachment to the implants and use a coverdenture as prosthetic superstructure. These systems, it is argued, are better accessible for self-performed oral hygiene. The experience of thousands of patients treated with BOI implants shows that this claim is unfounded. The truth is that fixed prosthetic solutions that are both aesthetic and accessible can be provided even in the most unfavourable of situations. In our view, the predilection of crestal implantologists for screwed bar attachments really has to do with the high rate of implant loss with these designs. The true reason is that these losses can be "administrated" better under screwed bar attachment than under cemented bridges, thereby avoiding the financial risk (i.e. the laboratory costs) of having to replace the superstructure every time an implant is lost. Screw connections offering a precise fit are much more difficult to realize than cemented connections, particularly in situations where the bone morphology has changed over the course of treatment and if conditions in the try-in phase are no longer the same as in the phase of impression-taking.

Some users prefer to remove the prosthetic superstructure at regular intervals. This naturally requires the use of a screw connection. Cemented bridges are not an option in that case.

One of the reasons why screw connections are more convenient to use on rigid implants (types IDO, IDOT or ID) is because screw-retained bridges cannot develop pre-loads along their basal components. On the other hand, internal-thread systems are associated with large implant heads of adequate wall thickness, which entails larger mucosal penetration points, thereby increasing the risk of infections.

Other users do not wish to remove the bridges ever again. Therefore, they have no occasion to embark on the technically demanding task of establishing a screw connection. After all, the time and money going into the fabrication of a screw-retained bridge would suffice to fabricate two simple bridges from scratch. Anyway, a new bridge (even a simple Brosamle-type bridge) is often the better solution in the event of complications. We therefore use cemented bridges instead of screw-retained bridges whenever possible and advise our patients to spend less money on one specific restoration but to have new restorations fabricated from time to time instead. As a matter of fact, new restorations will be needed automatically as the old ones are reduced over time by the necessary occlusal adjustments.

In our practice, ED-type implants have yielded the best results. This presumably has to do with their high resistance to infections, which we attribute to the thin polished surfaces at the level where the implant penetrates the mucosa. The screw connection can virtually always be established outside of the mucosa. In this way, the connections are well accessible and self-draining.

To summarize, every approach has specific advantages and disadvantages. A panacea does not exist. Regarding the question under discussion here, the universities repeatedly switched sides every few years. It is safe to assume that these changes of heart were prompted not so much by first-hand deliberations and experience as by dependence on third-party funding at the hands of specific implant manufacturers.

7.7 Reducing Functional and Parafunctional Loads by Prosthetic Treatment

Adjusting the position of the masticatory surfaces can create a situation that helps to reduce the masticatory forces by loading the TMJ structures.

The consequences of great masticatory forces are also apparent in patients wearing dentures. Mercier and Lafontant (1979) observed more advanced cases of ridge resorption in patients characterized by small lower faces and horizontal orientation of the mandible (i.e. small gonion angle). They also mentioned that the attachments of the jaw-elevating muscles were located more anteriorly in those patients. In the patients who showed a relatively open bite, the last functional molars were located somewhat more anteriorly to the front margin of the chewing muscles participating in closing movements. Presumably, the orbicularis oris muscle is more strongly involved in chewing-related closing movements in those patients.

Taking advantage of the good integrative capacity of the distal mandible, we invariably place BOI implants in its terminal segment or under the linea obliqua (white line in the OPG). The endpoint of prosthetic function is at the position of the first

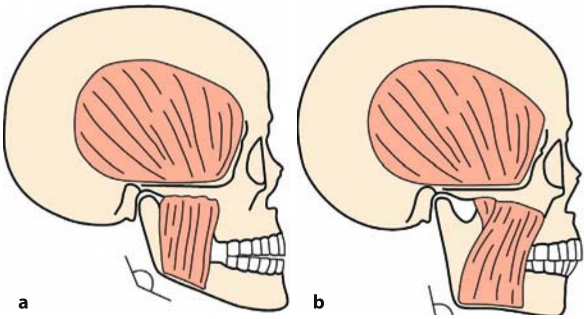


Fig. 7.5a,b. The positional relationships between the dental arches and muscles may vary. The situation on the right is characterized by a small gonion angle and a distal position of the masticatory surfaces. The TMJ is protected from high chewing loads exerted by the dental arches, which is why there is no negative feedback on excessive forces. This increases the risk of parafunction. On the left side, by contrast, the vertical muscle forces are not blocked by the dentition and fully impact the joint area. The masseter muscle has an anterior and a posterior part, and any weakness of one of these parts may lead to differences in load propagation to the joint during mastication and parafunctional activities (modified from Mercier and Lafontant 1979)

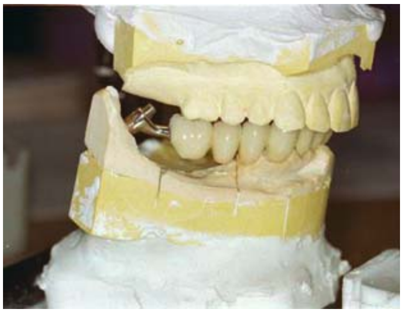


Fig. 7.6. While the distal positions were selected for the BOI implants because of their biomechanical stability, no masticatory surfaces are required distally to the first molar. The pontics are designed with a mucosal clearance, so that they cannot interfere with the crestal growth of the mandible

molar. In this way, we artificially create a situation like the one illustrated on the left side of Fig. 7.6. In the postoperative remodelling phase, the morphology of the mandible changes by bending slightly upwards towards the caudal aspect. This gives rise to premature contacts in the distal posterior segment that have to be periodically adjusted. If these adjustments are performed late or not at all, the implants in the mandible or in the opposing jaw may be affected by overload osteolysis.

7.8 Reducing Functional Loads by Drug Treatment

The chewing force needs to be reduced in the early postoperative phase to preserve initial bone contact as bone structures are being repaired. We instruct our patients to confine their diet to soft foods that are not chewed at all or can be chopped through in a single bite. Nevertheless, there are always some patients who do not grasp the meaning of "careful" and fail to understand the implications of adaptation losses. Patients with parafunctions who are aware of their problem and are found by the dentist to perform excessive biting movements as well can be prophylactically treated with drugs that reduce masticatory forces.

One option would be to reduce the activity of the entire organism by medications like oral meprobamate. Note that these patients will not be able to drive a car for the duration of treatment.

It has therefore become increasingly popular to use drugs with local activity such as botulinum toxin (Sommer and Sattler 2001; van Lindern 2000). Results based on relatively large patient samples are now also available for the treatment of bruxism by infiltration of the posterior temporalis muscle and/or the masseter muscle (Chikhani et al. 2001).

The following dosage specifications for botulinum toxin are based on the commercially available preparations Dysport or Botox. These products are packaged as a dry substance bound to human albumin that is reconstituted by the user with a sodium chloride injection (0.9%) to yield a solution. The product has to be stored in a cool place and transported in a refrigerated state. Once reconstituted, Dysport has to be used within the same day. One package contains 500 units of the dry product, which will suffice to treat up to two patients.

To minimize costs, it may be useful to schedule treatments such that the package can be shared between two patients. The preparation must not be shaken during reconstitution to avoid inactivating the active ingredient, which is not too stable.

Dysport blocks cholinergic transmission along the motor endplate by inhibiting the release of acetylcholine. Initially, the mode of action is directed at binding the extracellular receptors in a specific and saturable manner. Subsequently the toxin is internalized. The nerve endings of the motor endplate will no longer respond to neural impulses, and the chemotransmitter is not released. Presumably, the structures of the motor endplate are disintegrated by chemical action once the toxin has advanced into the cell.

Impulse transmission is restored as nerve endings and motor endplates are being re-established in the phase of regeneration, which will start around 8 weeks after the toxin was administrated. While the newly formed structures are anatomically different from the previous ones, they are nevertheless fully functional. It is not recommended to use several applications in series, as the consequences of this approach have not been investigated.

7.8.1 Dosage

A dose of approximately 500 units would theoretically suffice to appreciably block the masseter or temporalis muscle. An overly low dose will reduce the duration of action because any residual muscle movements associated with subtotal inactivation will stimulate the blood supply to the point of flushing the active ingredient away. Therefore, the dose level per muscle should be in the range of 100–250. The preparation should be injected at two separate sites, preferably at the jaw angle and the adjacent parts anterior to the masseter muscle.

If the masseter muscle is blocked only, the patient will attempt to restore his or her normal masticatory force by boosting the activity of the temporalis muscle. Thus the only way to ensure that the masticatory forces are safely reduced is by inactivating both muscles in a bilateral manner. Muscle inactivation will begin within 1–3 days of injection and last for 2 weeks up to 5 months at a mean duration of 2 months. The effect is building up gradually. It begins near the injection site and will then spread throughout the muscle in a matter of 2–3 days.

Treating the temporalis and masseter muscles on both sides of the jaw will take around 400–800 units. While this dose level is far below the lethal range of 39,200–78,400 units in humans, this range refers to the systemic toxicity. Any local applications that reach the myocardium, for instance, would be life-threatening even at therapeutic doses. The drug has to be transported in a refrigerated state and carefully stored.

The solution is injected intramuscularly, preferably through an extraoral access. The force peaks of the muscle are preferred sites of application. They can be located by voluntary muscle flexing.

7.8.2 Adverse Effects

If the masseter muscle is inactivated only, the mandible will advance to the point of generating excessively strong anterior contacts. Other chewing muscles, notably the lateral pterygoid muscle, may respond to this with diffuse pain reactions. Any swallowing-related symptoms are usually due to subjective changes in reflex mechanisms, provided that the injection was correctly performed. Salivation may also be subjectively increased. Anterior relocation of the mandible needs to be monitored and accompanied by occlusal adjustments if necessary.

Other adverse effects include paralysis of neighbouring muscles, which is usually reversible. Emergency ventilation should be available on short notice, since respiratory muscles may also become involved if the injection is not properly executed. An antidote is not available.

As the mandible may undergo anterior repositioning on losing the balancing support provided by the masseter muscle, temporary restorations inserted in this phase have to be adjusted in a timely manner to avoid excessive loading by prosthetic or masticatory forces.

We have observed many cases in which the mandible underwent significant relocation after injection of Dysport. In our view, this phenomenon is due to a process of relaxation or reorientation of the entire masticatory apparatus in which muscles spasms are resolved that have always been present but remained undetected and never resolved spontaneously.

7.8.3 Indications and Rationale

7.8.3.1 Prophylactic Administration

Generally speaking, any newly installed load-transmitting surfaces in bone-implant interfaces should be protected against shearing forces and deleterious overloads until an adequate load-resistant integration of the enossal titanium surfaces has been reached.

The focus of local muscle blockade in dental implantology is on situations where extensive clusters of chewing muscles can be readily identified by visual examination or palpation. Treatment is also indicated in patients who report having a record of nocturnal muscle activity and who exhibit advanced denture-related pressure atrophies. These patients are unable to control their masticatory forces in a voluntary manner and appear to be relatively tolerant or, for that matter, indolent with respect to oral symptoms (e.g. pressure sores).

Furthermore, treatment with botulinum toxin is also indicated in patients who evidently have a poor “sense of direction” as far as oral function is concerned. These patients tend to develop excessive habitual forces in a wide variety of chewing areas that are not directly associated with mastication itself but are triggered in an involuntary and uncontrolled manner. In our experience, these mechanisms are most likely associated with psychological factors. Both extroverted and inhibited personality structures could be affected. Patients with eccentric parafunctions, which frequently go undetected in practice, are rendered unable to use the full force of their muscles as well.

Advanced ridge resorption involving papyraceous thin bone walls, notably in the maxilla, is another situation where the chewing forces may need to be reduced.

During sleep the mandibular position differs from the position during the day. Muscular dynamics during sleep are unique to that during voluntary clenching and exert a greater mechanical load on the balancing side temporo-mandibular joint (Minagi et al. 1988). Therefore forces exerted on the peri-implant bone cannot be controlled by the patient during the night as they can during daytime. This is another reason why in cases with a compromised bone supply (especially in the upper jaw) the application of botulinum toxin must be considered.

Patients who presumably develop great forces on closing their jaws can also be identified by remote radiographs. Möller (1966) reported that the activity of the masseter and temporalis muscles varies depending on the inclination of the mandible, characterized by increasing amplitude in an anterosuperior direction as the mandible rotates. The gonion angle is small in these cases. Findings to the effect that the masseter muscle is most active in individuals with a small gonion angle were also reported by Witt (1963). Ingervall and Thilander (1974) observed a distinct relationship between facial morphology on the one hand and muscle activity during chewing as well as maximum intercuspidation on the other. During function, the amplitudes of the masseter and temporalis muscles were higher when the jaw bases were parallel but also when the mandibular occlusal line and the Go-Gn line were parallel. Strong chewing forces were associated with smallness of the lower faces and perpendicular jaw angles. Sassouni (1969) reported that muscle forces were three to four times stronger in patients with a small vertical dimension than in patients with a relatively open bite.

Any teeth located between the muscle ends can obviously reduce the forces to be absorbed by the TMJs. Lim Kheng (2000) demonstrated in this connection that chewing forces increased when the TMJ area was anaesthetized at the time of measurement.

In situations where several of the above-mentioned factors are simultaneously present, the use of botulinum toxin should be considered all the more, especially if strategic abutments are planned.

The prophylactic use of botulinum toxin is certainly indicated in patients with severe osteoporosis who are treated with maxillary implants.

7.8.3.2
Therapeutic Application of Botulinum Toxin

Even BOI implants that have been firmly integrated for many years may suddenly become mobile. These situations are usually caused by alterations at the masticatory surfaces. We have routinely observed cases in which major areas of mastication were lost in the opposing jaw of total BOI-based bridges. Unless these masticatory surfaces are replaced in a timely manner, a unilateral chewing pattern will develop and give rise to implant mobility. The reasons for this are as follows:

- The process of comprehensive remodelling leading to the development of new load-transmitting trajectories will per se compromise the stability of the implants.
- Unilateral chewing is liable to excessively load the implants on that side of the jaw.

Implants that were well integrated the first time around have a good chance of recovering their stability as long as the decalcified matrix in the granulation tissue has not been remodelled and the situation is not exacerbated by any infections along the load-transmitting surfaces.

The treatment requirement in these situations is to eliminate the cause of excessive loading without delay. One way of achieving this may be to insert additional implants in the opposing jaw (and, of course, in the affected jaw if necessary). Anyway, the treatment must be aimed at restoring a balanced chewing function. At the same time, the chewing forces are reduced by administration of botulinum toxin. The chances of reintegration are substantially improved by this precaution. We have observed cases in which highly mobile bridges stabilized in a matter of weeks after performing these two measures.

In our view, the use of interceptors is not a viable alternative to the treatment described above. After all, these devices rely on muscle-generated stimuli focused on a small number of teeth that are designed to reduce the chewing forces by inducing pain. Implants do not have proprioreceptors.

Splint therapies, TENS devices and suchlike are not helpful either. All these alternative approaches are unable to deliver the required effect, which is to relieve the implant-bone interfaces of any excessive forces whatsoever for a defined period of time (approximately 2 months).

One may be tempted to argue that treatment with botulinum toxin must be equally deleterious since the chewing forces will return to their old levels after treatment. This argument misses the point. After all, an increase in masticatory load is appropriate and indeed necessary once the implant-bone interface has consolidated to the point of offering adequate support in order to improve bone quality in the interface area.

Note that the muscles will shorten as their activity increases with the recovery of chewing forces once the toxin is no longer effective. Therefore, the distal portions of the prosthetic superstructure, which has homogenously settled in the intraoral space during healing, need to be extensively reduced to avoid excessive loading.

7.9 Extraction Versus Preservation of Natural Tooth Structures

Restorative dentists are routinely faced with the question of whether specific teeth should be extracted or preserved. The option of preserving teeth always warrants some scepticism. We should always remember in this context what our patients actually expect from prosthetic treatment.

Consider the following points:

- Seriously compromised teeth should not be included in the prosthetic structure unless there are good reasons to do so. Specifically, the dentist may choose to include any residual teeth in the temporary restoration to absorb the forces developing in the early phase of treatment while the masticatory pattern is being extensively reconfigured. Subsequently, these teeth can still be extracted or replaced by implants for the definitive restoration.
- Restorations that are supported by implants only while bordering on residual teeth whose prognosis is uncertain always carry the risk of incurring substantial complications if those teeth are sooner or later lost and need to be replaced after all. It is therefore better to consider extracting any such adjacent teeth right away and incorporate these locations into the restoration in the first place. This strategy has been shown to be more economical in the long run.
- The simplest solution in many cantilever situations is to incorporate anterior teeth. As will be shown in Chapter 12, inclusion of canines results in very durable restorations. Tooth-supported bridges extending from a distal to an anterior abutment are a well-established conventional prosthodontic technique. There is no reason to use a different approach for implant-supported bridges.
- Before replacing a first molar in the mandible, one should carefully assess how this approach compares to a conventional tooth-supported bridge with the second molar as abutment. While we have scarcely observed any complications with Type 3c and Type 4 structures, it is nevertheless worth noting that the position of the first molar will rarely offer a truly strategic position for implant placement (with respect to an edentulous mandible). Therefore, if the second molar is expected to last for another 5–10 years, we would always prefer a crestal implant solution or a conventional tooth-supported bridge to a BOI-based solution. Alternatively, if the second molar has a poorer prognosis than that, we would replace it with a BOI implant either alone or in combination with a tuberopterygoid screw.
- Root canal teeth should be incorporated as abutments only if the root canal filling was successful and if the crown offers enough retention (after introducing a cast dowel core if necessary).

7.10 Temporary Restorations

Depending on the therapeutic scope and the treatment schedule, the implants may have to be fitted with a temporary bridge in order to restore the patient’s chewing ability, but also to test the occlusal level, the occlusal relationships and the masticatory function. In other words, the temporary restoration is a very important element of the overall treatment plan. The phase of provisionalization may last between 2 and 9 months, in some patients it may take more than a year. Anyway, the exact duration is not a major concern as the patient is never left without fixed teeth. In the presence of excessive gap formation under the pontics, the dentist may choose to insert a temporary epithesis or to substitute a second temporary bridge.

7.11 Scope of Restorative Treatment

If the occlusal table is not equally long on both sides of the jaw, the patient will sooner or later develop a preferred chewing side. This will normally be the side where the occlusal table extends farther into the distal jaw segment. This situation may give rise to implant fracture or to undesirable asymmetries of the jaw in terms of shape and mineralization. In this process, sites that would normally lend themselves to implantation may become unstable and vice versa. Establishing functional symmetry is a matter of top priority if a reliable treatment plan is to be established. This goal may be difficult or even impossible to achieve in restorative treatments where parts of the natural teeth have to be left in an unfavourable condition.

Even if symmetrical relationships have been established, this situation is unlikely to remain stable. Rather, the cranial bones will undergo continuous morphological changes. As part of this process, the position of the masticatory surfaces will be continuously altered as well. Subtractive and/or additive occlusal adjustments are needed to reflect these changes. If they are not performed in time, the bone-implant-restoration system will tend to lapse into unilateral functional patterns with serious consequences for the preservation of the system at large.

For the implantologist, these points are in sharp contrast to the philosophy of osseointegration. It is nevertheless a false premise to think of implant-restoration systems, no matter how well they are osseointegrated, as being immobile in the context of the skull, considering that the cranial bones are themselves subject to deformation and mobile relative to each other. Implants, by contrast, do not possess the ability of natural teeth to adapt by elongation. On the other hand, changes of the horizontal bone level can frequently be identified as relative elongation (besides bacterial influences, which have a great impact particularly in crestal implants). It is therefore necessary to understand the biomechanics of the overall system and to establish reference points that go beyond the immediate vicinity of the inserted implants. This "big picture" cannot be captured by small-scale images.

The scope of restorative treatment is defined by the treatment objective, which is to establish an adequate, stable and symmetrical chewing function.

7.12 The Significance of Third Molars

As a general rule, the upper third molars are removed before BOI treatment. In rare cases, if the position and root relationships are favourable, they can be incorporated as distal abutments. Situations in which a third molar can be left "as is" are extremely rare.

Any wisdom teeth in the mandible that have no contralateral counterpart should be removed as well, even if they do not participate in mastication and do not seem to involve any problems on the face of it. The fact is that third molars will sooner or later alter the masticatory plane; if they are present unilaterally, they are consequently liable to induce biased chewing patterns (Sato 1987). We do not suspect that third molars exert any "forces" on the anterior teeth per se. Their presence does deflect the macrotrajectories of the jaw. The results in a prolonged phase of remodelling compared to situations where eruption-related remodelling is completed after the second molar has erupted. This

Fig. 7.7. The decision to take out 3rd molars is sometimes difficult to make, since their removal triggers extensive remodelling and large defects are found after extraction. In the case shown here, further eruption of 18 had to be expected, which also caused remodelling that led to a loss of integration of the BOI implant in Region 16. The remaining tooth also provided a considerable bacterial pool, and 3rd molars block the resorption-resistant area of the tuberosity. It is recommended either to use the 3rd molar as abutment or to extract it as part of the therapy.

prolonged remodelling will extend into a phase of life when the hormonal situation is no longer directed at building up bone volume. Enhanced remodelling in this phase of life will therefore, on balance, cause the bone volume to decrease in absolute terms. From the dentist's perspective, the teeth are becoming increasingly crowded.

"Crowding" means that the space requirements for the clinical crowns (outside of the bone) are at variance with the bone volume surrounding the roots.

According to today's aesthetic expectations, the crowns of the anterior dentition should ideally look like pearls arranged along a necklace. Such an arrangement is only possible with symmetrical and space-occupying roots. For this purpose, bone volume is needed in the non-supportive area between the roots, even though this bone is irrelevant for the structural integrity of the jaw. The secondary osteons enclose the vestibular and lingual aspects of the roots like belts. These belts have to be narrowed to save bone for the rounded tooth structures in the anterior segment. This process brings the roots closer to each other and gives rise to the fanned-out arrangement of the anterior crowns. This development may be arrested if the anterior teeth are retained by orthodontic treatment over many years until the phase of growth, eruption and associated remodelling has been completed. If any third molars have not been removed, this steady state will not be reached for many years to come. Delayed removal after the age range of 12–14 years has two disadvantages:

- Growth-related remodelling will last longer.
- By this time, space has already been occupied by

the third molars, and resorption of the anterior ramus with relative elongation of the horizontal branch has taken place as well.

But why does the eruption of third molars have such far-reaching implications? This question can only be addressed for each jaw separately.

- The mandibular third molars erupt in areas that are crucially important for the stability of the jaw. Tooth eruption is preceded by osteolysis in the crown region. Enzymes will additionally soften the bone structure where eruption is to take place. If the bone through which the third molar erupts is a load-bearing structure, which is the case in the mandible, this structure needs to be replaced immediately. This new bone formation usually occurs vestibularly to the crown (i.e. vestibularly to the area where the root will be located after eruption has been completed). Depending on the location of the macrotrajectories, the third molar may erupt in the centre of the ridge or in a lateral position. In young patients who require significant cortical bone structures because of high chewing forces, the macrotrajectorially oriented cortical bone structure in the area of the jaw angle will be deflected in a more lingual direction if the third molar does not erupt directly from the ridge, thereby giving rise to the well-known lingual projections along the distal ridge. In addition, third molar eruption will also influence the (vestibular versus lingual) macrotrajectories of the first and second molars.
- The dentulous horizontal branch of the mandible remains largely unchanged during growth over many years, while the ramus grows in a cranial and distal direction. The anterior segment of the ramus does not undergo resorption until the second and third molars erupt. Indeed, they would not be able to erupt otherwise. The horizontal branch of the mandible is stretched in this process. Whether adequate resorption from an anterior direction is possible depends on the strength and direction of the muscle structures. The masseter muscles in particular can be attached in such a way that adequate resorption cannot take place because the mineralization tendency of the anterior ascending ramus is more powerful than the tendency of the third molar to create osteolysis. This will give rise to situations of (partial) retention.
- In the maxilla, Camper's plane has to descend for third molars to erupt (squeezing-out effect) because there is not enough space for all three molars as long as the maxilla has a distocranial orientation. The eruption and growth tendency is counteracted by chewing forces. Third molars cannot erupt in the maxilla if very powerful chewing forces are present because the masticatory plane will not descend far enough to create the necessary space at these dorsal sites.
- Situations where mandibular third molars are removed and replaced with implants after having been in place for many years will usually result in a relative elevation of the crestal bone level in the affected area because the area of the mandibular angle can only develop its biomechanically optimal macrotrajectorial orientation after the tooth has been removed. While those molars are present, they will keep the alveolar crest low due to the chewing forces involved. Maxillary third molars that are impacted or partially impacted do not lead to this effect because they are at the mercy of the macrotrajectories in the absence of any masticatory stimuli after their roots have developed. It is not always easy to predict whether or not the ramus will undergo anterior relocation after mandibular third molars have erupted. As a matter of fact, problems for implant treatment in that region are sometimes caused by anterior expansion of the soft-tissue structures alone.
- Orthodontists frequently argue that third molars should be extracted because they induce crowding in the anterior segment. While we do not agree with this explanation per se, we do see a causal relationship after all, in that the prolonged remodelling in the area of the third molar induces remodelling in the anterior segment as well, thereby reducing its volume.

As with implants, the bone-preserving effect of roots that are subjected to mechanical forces only extends slightly beyond the lamina cribrosa at best. We should also consider that the opportunity to preserve teeth in the long term even in older patients is essentially an achievement of modern dentistry. From a biomechanical viewpoint, a complete dentition can only be preserved for a lifetime at the expense of extremely straining the bone volume. If the first molars were affected by caries or had to deal with sufficiently abrasive foods early in life, there would normally be enough space for the third molars to erupt with no need for the masticatory level to descend. Considering the efforts aimed at tooth preservation and to meet aesthetic expectations, it is usually justified to extract any third molars right away.

In our experience, third molars should usually be extracted in connection with BOI treatment unless they can be incorporated into the restoration to good effect. The location of dislocated third molars in the maxilla usually coincides with the site that is required for strategic implant positioning. If removal of the third molar is associated with vestibular cortical bone loss, a two-stage surgical procedure must be considered.

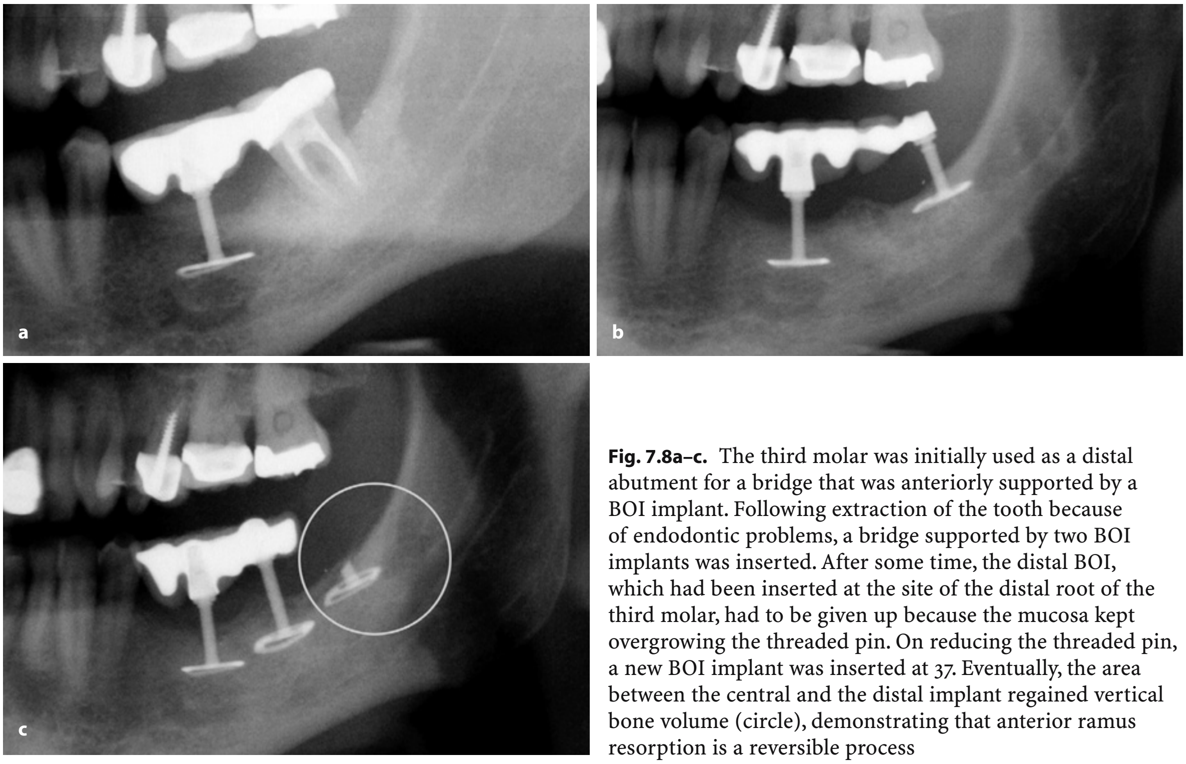


Fig. 7.8a–c. The third molar was initially used as a distal abutment for a bridge that was anteriorly supported by a BOI implant. Following extraction of the tooth because of endodontic problems, a bridge supported by two BOI implants was inserted. After some time, the distal BOI, which had been inserted at the site of the distal root of the third molar, had to be given up because the mucosa kept overgrowing the threaded pin. On reducing the threaded pin, a new BOI implant was inserted at 37. Eventually, the area between the central and the distal implant regained vertical bone volume (circle), demonstrating that anterior ramus resorption is a reversible process

Fig. 7.9. While the macrotrajectories of the mandible extend vestibularly from the ascending ramus past the teeth, the teeth are forced towards the lingual aspect. The tongue provides the necessary counterforce. Between the canines, the statically supportive macrotrajectories proceed on the lingual or vestibular aspect of the teeth at the root level. Following extraction of the teeth, they invariably move towards the lingual aspect. The necessary counterforce for the position of teeth in the dentulous anterior segment of the mandible is provided by the orbicularis oris muscle. The canine is located at the centre of the trajectories. Distally to the canine, the macrotrajectories are increasingly orientated vestibularly to the teeth. They cross this line in the root area of the premolars

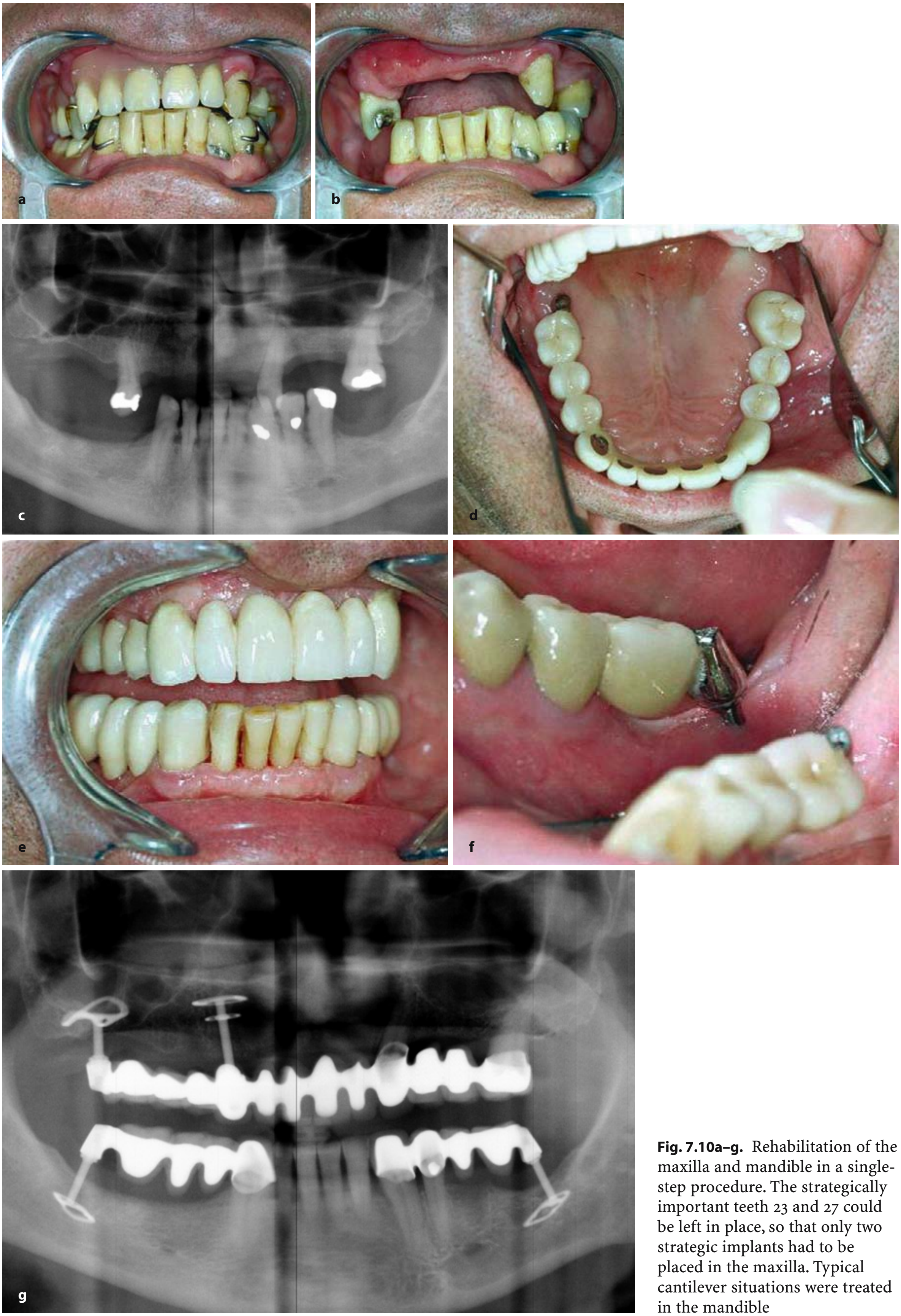


Fig. 7.10a–g. Rehabilitation of the maxilla and mandible in a single-step procedure. The strategically important teeth 23 and 27 could be left in place, so that only two strategic implants had to be placed in the maxilla. Typical cantilever situations were treated in the mandible

The prosthetic design should take into consideration that while bone resorption is centrifugal in the mandible, the macrotrajectories will relocate centripetally in a medial direction.

7.13 Summary

The path toward fixed restorations must always be based on a correct occlusal plane.

1. A sort of balanced masticatory function is more easily achievable to provide if a complete denture is present in one jaw, while the other jaw (usually the mandible, where acceptable retention of a complete denture is much more difficult to achieve) is treated with an implant-supported fixed restoration that may or may not include any natural abutments. If the opposing jaw contains a fixed restoration, measures must be taken to facilitate equilibration following BOI therapy.
2. Especially in the early phases of treatment, all contacts should be located within the support polygon marked by the greatest circumference of the base plates of the disks. This requirement must be borne in mind when designing the restoration. The technician will require clear instructions as to the size of the bridge as well as the type and location of the cusps involved. These instructions can be derived from the size of the disks on the one hand and their spatial orientation on the other. This does not apply to the anterior region, where the restoration will be designed in accordance with functional and aesthetic requirements.
3. A structured occlusal relief is required to facilitate the crushing of food.
4. The occlusal surfaces must be adequately wide. Small and narrow surfaces, as considered desirable by crestal implantologists, will prevent a bilaterally balanced mastication pattern.
5. The design principles for the occlusal surfaces and planes in BOI-based restoration are actually more in line with complete dentures than with tooth-supported fixed restorations.
6. Any teeth in the opposing jaw must be adequately supported on an individual basis. Any teeth protruding from the occlusal plane need to be reduced.
7. In the presence of dysfunctions, it is recommended to provide a fixed restoration for the mandible while performing balancing treatment in the maxilla – using a temporary complete upper denture if necessary. This d-tour may be quite often necessary for financial reasons. In general it is always better to provide fully fixed upper and lower arches and this is, what should be recommended to the patient. Only with fixed teeth permanent balance can be established.

7.14 Final Comments

Apart from what has been said in this chapter, there is also a case against switching patients directly from fixed tooth-supported to fixed implant-supported restorations. It takes some patients the experience of wearing a denture to appreciate the high comfort of fixed teeth. If the continuity of fixed restorations is never broken, those patients may never know what life would be like without fixed teeth. This lack of appreciation may reduce the patient’s compliance and willingness to fulfil his or her own contractual obligations in the long term. In this way, an interval in which the patient has to wear a removable restoration may even be advantageous.