# Restoration of the Atrophied Mandible Using Basal Osseointegrated Implants and Fixed Prosthetic Superstructures

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*The nonremovable reconstruction of the atrophic mandible is possible with basal osseointegrated implants in an immediate-load procedure. Between 4 and 5 implants are necessary to form a reliable foundation for a fixed bridge. The vertical dimension and the aes*

*thetic appearance may be reconstructed in the desired way. (Implant Dent 2001;10:41–45)*

***Key Words: basal osseointegration, immediate load, fixed prosthesis***

In crestal implantology (crestal implantology: Implants are referred to as crestal-type implants if they are inserted into the jawbone coming from the crestal alveoli and whose main load-transmitting surfaces are vertical. The term thus covers screws, cylinders, and blade implants.), it is standard practice today to insert screws at least 10 to 13 mm in length in the anterior segment of the mandible because this part of the mandible usually offers sufficient vertical bone. Depending on how many screws this area can accommodate, patients will receive intramucosal abutments, bar attachments, or bridges with cantilevered pontics.

Patients with very little available vertical bone are at a particular disadvantage. The prosthodontic structures in these patients are usually planned so that only a small percentage of the masticatory load will be directed to the implants. Anterior crestal implants will often offer only rudimentary support for a removable denture that is essentially borne by the oral mucosa. Superficially, this approach seems to reduce the problem of support. However, providing removable dentures does not actually resolve the underlying process of debilitating tooth and jawbone loss. This therapy concept is probably still considered viable today because the debilitation is more or less not noticeable.

These considerations have prompted the author to forego the "conventional" approach in favor of basal osseointegration (basal osseointegrated implants: These implants are inserted into the jawbone coming from the lateral aspect. Masticatory load transmission is confined to the horizontal implant segments and, essentially, to the cortical bone structures.), especially in extremely atrophied mandibles (Fig. 1). Over the years, based on clinical experience, a precise, fast, and inexpensive treatment procedure has been developed to optimize the implants, the surgical technique, and the dental treatment and follow up. (We have exchanged and continue to exchange our insights and results with the members of the German Implantoral Club (ICD).) (German Implantoral Club: Professional association of prosthodontists working with basal osseointegrated implants, oral surgeons, and maxillofacial surgeons. Founded in 1989.)

It is precisely the heavily atrophied mandible that is, in principle, best suited for fixed dentures. The mandible with its tubular structure has to accommodate strong muscular action. Hence, it features a high bone turnover rate that is stress-related, affording optimal bone regeneration after each osteotomy and very good regeneration in osteolysis of different etiological origins.[1,2]

It does not take many implants to set up an implant-based fixed denture system that can support a stable, immobile bridge on a twisting and rather unstable underlying mandible—similar to an external fixating device. Even as Linkow[3] developed his tripod subperiosteal and ramus frame implants, he had realized the principle that potentially favorable and stable long-term implant positions are not only found between the mandibular foramens, but also, and specifically, in the well-ossified distal aspect of the horizontal mandibular ramus, as well as in the transitional zone toward the ascending ramus. Spiekermann[4] coined the term "strategic implant placement," even though he was presumably referring to the maxilla and, specializing in screwed implants, he lacked suitable implants for fixed dentures for the atrophied mandibular ridge.

Our own treatment approach to extremely atrophied ridges based on

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ISSN 1056-6163/01/01001-041$3.00
Implant Dentistry
Volume 10 • Number 1

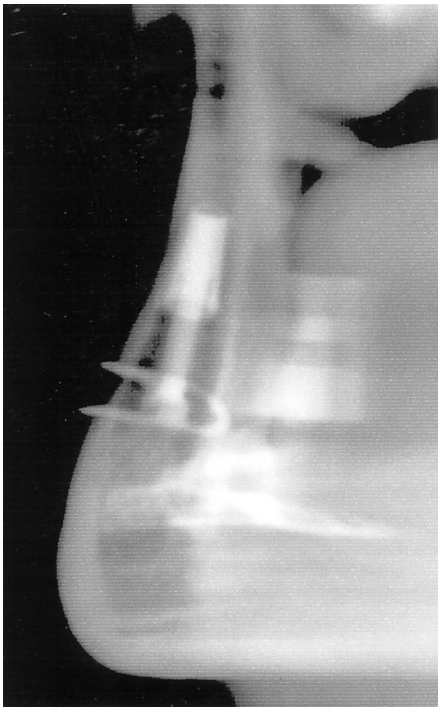

**Fig. 1.** This lateral tomograph taken immediately after insertion shows regular bicortical anchorage of the BOI.

basal osseointegration draws on the results of Linkow,[3] Roberts,[5] and Spiekermann.[4] It has developed into a viable long-term therapeutic concept.

In recent years, two schools of thought have emerged in the area of basal osseointegration:

1. The French school of Scortecci and others favors restoring even severely atrophied mandibular ridges by using a large number of basal osseointegrated implants (BOI), usually 7 to 12 implants. This school combines BOI with screw implants, both in the maxilla and in the mandible. The implant systems thus established are immobile and do not allow jaw regions to change their relative orientation.
2. In the German-speaking countries there is a tendency to favor restoring the edentulous mandible using only a few BOIs, usually inserting four implants in regions 47, 43, 33, and 37, even when providing fixed dentures (Fig. 2). This type of implant system is referred to as "flexible" because it permits mandibular shifts and flexion below the fixed superstructure, despite the fact that the load-transmitting segments of the basal implant osseointegrate. The long threaded pins between the load-transmitting osseointegrated disks and the bridge serve as flexible interfaces.

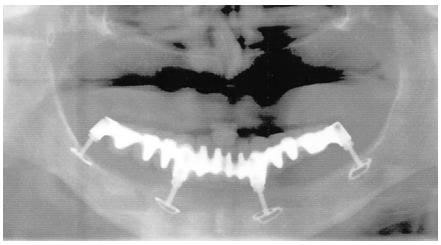

**Fig. 2.** A typical mandibular restoration with four BOIs in the strategically important implant positions; ie, in the regions of the canines and the second molars. The ceramic units are only in function up to the regions of the first molars.

The atrophied mandibular ridge rarely offers enough vertical bone for implant insertion, but, as can be readily palpated, there is usually sufficient available bone in the horizontal plane. The bone is optimally utilized by BOI implants inserted horizontally. In the past, clinicians attempted to maximize the number of implants inserted in the mandible, following general custom in dental implantology and the French school. It was shown, however, that BOI suffered from the influence of jaw flexibility in the regions of the second premolars and first molars, resulting in inferior osseointegration of the force-transmitting disks. But because this had no consequences on the stability of the overall design, the prosthodontic structures could be preserved in all cases. As a rule, 2 to 3 implants can be inserted in the anterior segment, whereas one implant can be accommodated in each distal mandibular segment.

## Anterior Implants

If sufficient vertical space is available, the implants used are usually the ones with two disks. The basal disk has a diameter of 9 or 10 mm, whereas the crestal disk is 7 mm in diameter. If the insertion of double disks fails due to the lack of available bone, a single BOI with a 7- to 9-mm diameter and shafts between 8 and 13.5 mm can be used instead. Disks $<9$ mm in diameter should be avoided; larger disks are rarely required.

## Posterior Implants

The implants used here are usually of a square shape, having a disk of $9 \times 12$ mm or $10 \times 14$ mm with shafts of 10 to 13.5 mm in length, depending on the desired vertical dimension and the available horizontal bone. The height of the disk itself is 0.6 mm: this allows the implant to participate in the flexion of the mandible and provides safe ground for the fixed bridge. In general, square implants are an excellent choice because the threaded pin, when inserted from the side, always arrives in a favorable medial position. The absorption of the distal mandible in a centripetal direction can, in part, be compensated during implant placement. The longitudinal shape of the implant results in excellent primary stability. Even wider mandibles no longer require large BOI disks offering rotational symmetry, facilitating minimally invasive implant-bed preparation instead. The best implant site is at the base of the heavily mineralized anterior corner of the ascending ramus that can be easily visualized radiographically.

If the vertical bone available above the mandibular nerve is $<2$ mm, infranerve implant insertion (infranerve implant insertion: The disk is introduced below the mandibular nerve; the threaded carrier is located at the side of the nerve.) is indicated. Lengthy implants are virtually useless for this purpose because the nerve will likely be located too far vestibularly. Instead, unilaterally square implants (often 9SG6, 9SG8) or the older round implants are used. In experienced hands, the technique of infranerve implant insertion is no more difficult than supranerve insertion. Using a sharp cutter or a round bur, the bony nerve canal is explored cranially, and the nerve is exposed. The important part is to explore the caudal extension of the nerve canal to prevent caudally displaced nerves from being injured by the cutter. If the nerve in the selected area is lo-

cated lingually, an infranerve implant cut is prepared from the vestibular aspect. If the nerve is located vestibularly, it is necessary to search for a suitable implant site further distally. In practice, the implant can always be inserted from the vestibular aspect because the mandibular nerve will eventually exit the mandible lingually. Infranerval insertion from the lingual aspect was never necessary, although theoretically this is an option. With BOI, the mandibular nerve rarely needs to be exposed and displaced.

The necessary manipulations in the nerve canal and almost of all the postoperative flap opening in a vestibular direction (tending to require traction and mobilization of the mandibular nerve) result in bland paresthesias, which will rarely persist beyond 3 months; if the paresthesias persists, it will be confined to the area of the chin. Of course, patients need to be informed of this possibility beforehand.

This concept of implant placement is abandoned only if the desired implant site lacks bone substance or if an implant is not an option for other reasons, such as in the presence of excessive periodontal breakdown or previous implant loss. In these cases, it is usually necessary to insert more than four implants for a complete mandibular denture.

Our long-term observation of many cases has shown that implant loss or osteolysis in the anterior mandibular segment is a rare occurrence. The same can be said of crestal implant systems; one factor certainly is that smaller masticatory loads act on a more stable bone. Also, due to the activity of the tongue and the jaw-lowering muscles, this bony environment always tends toward apposition of bone. In those rare cases where osteolysis did occur, these were unilateral in connection with distal BOI, usually due to denture imbalance and overload and frequently combined with infection resulting from poor hygiene. High initial tension acting on the bridge frame with elastic deformation of BOI in the area of the threaded pin can is also implicated.

Occasional unilateral distal implant loss was initially a surprise. After thorough analysis of this phenomenon based on routine follow-up orthopantomographs at 12 months, at which time most patients were either asymptomatic or had only mild complaints, pronounced osteolysis was invariably detected around the disk of the affected distal implant. No other implants were affected. To address this problem, the bridge was shortened and separated from the threaded pin of the affected implant, which would immediately come loose and had to be removed definitively. This indication to remove BOIs was summarized in a "Consensus on BOI."[6]

Evidently, implants not affected by osteolysis had assumed the whole task of transmitting masticatory loads to the mandible without the bone around the disks being appreciably damaged. Our next step would therefore be to shorten the bridge on the affected side, depending on the bite situation, back to the region of the second premolar, thus leaving the bridge in function.

A new implant is inserted after 6 to 8 weeks depending on clinical or prosthodontic requirements. Forty days are usually allowed for the new implant to heal. Subsequently, the mandibular bridge is either extended distally or is replaced.

Distal implant loss can be attributable to several causes:

1. Overload by unilateral early denture contact. Consequences of this overload manifest themselves mainly within 12 months of inserting the bridge. Later, the basal disks will be ossified to the point where the overload will more likely cause the bar attachment to break. Particularly at risk are patients who seek treatment elsewhere to have the denture rebased or crowns or bridges inserted in the opposite jaw. This is because many dentists lack experience with BOI systems and their correct appearance and will fail to adjust the occlusion accordingly. Patients are therefore informed that in the interest of their own safety, they should only seek dental treatment from dentists who are experienced with BOI.
2. Vertical relation too high. When the mandibular ridge is severely atrophied, dentists tend to be very conservative about the vertical occlusal relation of mandibular complete dentures. This is to prevent the denture from causing interferences as it is moving through the oral cavity and to ensure that the tongue can effectively control it. The use of BOI implants brings back the option to adjust the vertical relation correctly. Although this option is very much in line with the patients' esthetic needs, the vertical relation will further change as the temporomandibular joint is undergoing postoperative adaptation. The same effect is seen as the biting force recovers, which frequently requires extensive adjustments at follow-up. Patients who cannot cope with the new vertical relation are subjected to gradual subtractive treatment (reducing the occlusal surfaces to increase the vertical dimension) until they are at ease with the bite position. No possibility has yet been found to determine in advance which vertical dimension is tolerated by patients *in situ*. One of the most important reasons for increasing the vertical dimension is the concomitant reduction in masticatory forces.
3. Poor hygiene. In the earlier days, retention-related infections with the ribbed shafts of the old "disk implants" would sometimes be observed, but such cases are rarely seen with today's plain shafts.

Our experience does not support the belief frequently encountered in the literature[7] that medial and caudal torsion of the (atrophied) mandibular ridge poses an insurmountable obstacle to providing complete dentures. At least for BOI, this belief does not hold true, provided that the threaded vertical portions of the implants are chosen long enough. In our experience, the movement patterns of the atrophied ridge tolerates splinted implants in the anterior mandible and

prosthetic support on three or, better still, four sides (circular). Additional implants in the premolar area are relatively often lost (with no damage to the overall structure). Their use was therefore abandoned altogether in favor of safe implant areas.

It is also important to note that the implant is immediately loaded with the prosthetic superstructure, which ensures that the bone regenerates in a functionally sound fashion.

## Cost Considerations

BOI restorations can achieve a favorable ratio of implants to dental elements: with 4 or 5 implants supporting 12 (ceramic) dental elements, the ratio is between 1:3 and 1:2.4. Accordingly, the cost of the materials for fixed dentures for one jaw are quite low ($150 per implant, ie, $600–$750 for each jaw). In the maxilla, it is necessary to use double disks due to inferior bone quality compared with the mandible, increasing the cost by 30%. However, the smaller number of implants is only one of several cost-reducing factors. Others include the short treatment and the need for only one surgical intervention. On average, it only takes a total of 3.5 hours to restore an entire mandible. This includes the surgical intervention, framework try-in, bite registration, and definitive insertion of the superstructure.

## Temporary Bridge

The existing complete denture is cut back to the bridge and cemented onto the abutments. If the denture is missing or does not cover the implants, the temporary restoration is constructed using pulldown splints produced in our own laboratory using standard bridges. Although it is sufficient in principle to use three implants for the temporary bridge, inclusion of all four abutments is recommended, particularly if the temporary bridge is to worn for an extended period, ie, for more than 12 days. In the absence of procedural obstacles or significant postoperative swelling, the definitive bridges are integrated as early as on the third or fourth postoperative day. Often a temporary bridge is not needed, further reducing the risk of wound edge contamination.

## Definitive Restoration

The metal framework has to be exceedingly stable. To withstand the bending stress, it should preferably be cast from a nonnoble alloy. This ensures that ceramic material cannot chip off. The physiological movement of tubular bones such as the mandible involves significant traveling of the bone itself. Medial and caudal flexion will bend and twist the mandible by up to 2 mm.[8–10] Richter[11] therefore postulated that prosthetic structures in the mandible should always be divided into three parts. This prosthodontic approach is supported for crestal implants, which osseointegrate and transmit loads along their vertical axis.

Based on our own clinical experience, however, this is not a compulsory requirement in the case of BOI because the vertical implant segments do not have to osseointegrate for a BOI to be functional. It is only the basal horizontal load transmission surfaces that have to osseointegrate and transmit masticatory loads. The flexible threaded shaft between the basal disk and the prosthetic structure constitutes a perfectly serviceable interface that follows the torsion movements of the mandible.

Another postulate known from crestal implants is to mount the superstructure onto the implants in a tension-free manner. This is difficult to achieve in complete fixed BOI-supported dentures, notably in mandibular dentures that are loaded immediately. For immediate postoperative impression-taking, the mandible is closed as much as possible. The bridge frame is rarely tried in free of tension; in many cases it has to be readjusted. This can be attributed to functional bone dislocation that will cause a limited but persistent deformation of the mandible immediately after surgery. It has been observed that whenever this happens, the anterior segment of the mandibular curve will bend caudally.

When cementing the complete mandibular denture, the implant shafts are first fixated relative to each other. When the relation between bridge and implant is thus defined, the initial elastic movement of the threaded pin relative to the disk should be minimal. While the cement hardens, patients are instructed to slightly close in an occlusal position.

Basal osseointegration is currently the only procedure for treating extreme mandibular atrophy with a fixed prosthetic denture in a single surgical session. In our view, alternative procedures such as osseodistraction and ridge augmentation using bone from the hip, rib, or parietal skull are obsolete. Those techniques use unsuitable implants requiring cumbersome and risky preliminary interventions to obtain the bone used for those implants instead of using implants actually suited for the available bone.

This is not to say that implant and bone loss cannot occur with the basal osseointegration technique. The bone loss can be controlled, however, by frequently recalling patients and ensuring timely and competent intervention. Unlike many treatment failures using crestal implants, the type and extent of those cases was limited enough to allow insertion of a second BOI denture.

## Conclusions

The atrophied mandibular alveolar ridge can be restored using basal osseointegrated implants, allowing the integration of complete fixed dentures. As a rule, the laterally inserted implants can be subjected to moderate loads immediately.

The basal osseointegration procedure is advantageous for the patient because it allows speedy reconstruction of the masticatory function, and the cost of treatment is very moderate. Additional surgical interventions to facilitate access to screw threads in the mandible are not required.

Basal osseointegration procedures allow the insertion of complete fixed dentures both in the maxilla and in the mandible.

## Disclosure

The author has a financial interest in Dr. Ihde Dental AG Switzer-

land, whose implants are mentioned in this article.

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# Abstract Translations [German, Spanish, Portuguese, Japanese]


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***ZUSAMMENFASSUNG:*** Die festsitzende Sanierung des zahnlosen Unterkiefers gelingt mit Hilfe von basalosseointegrierten Implantaten (BOI) in einer Sitzung und in Sofortbelastung. Mit wenigen Implantaten lassen sich zuverlässige Fundamente für zirkuläre Brücken erstellen. Dadurch kann auch die vertikale Dimension und die Aesthetik in gewüncschter Weise wiederhergestellt werden.



***SCHLÜSSELWÖRTER:*** basalosseointegrierte Implantate, Sofortbelastung, feste Brücken



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***ABSTRACTO:*** La reconstrucción no removible de la mandíbula atrofiada es posible con implantes oseointegrados basales en un procedimiento de carga inmediata. Entre cuatro y cinco implantes son necesarios para formar una base confiable para un puente fijo. La dimensión vertical y la apariencia estética podrá reconstruirse en la manera deseada.



***PALABRAS CLAVES:*** oseointegración basal, carga inmediata, prótesis fija



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***SINOPSE:*** A reconstrução não removível da mandíbula atrófica é possível com implantes ósseo-integrados basais em um procedimento de carregamento imediato. Entre quatro e 5 implantes são necessários para formar uma fundação confiável para uma ponte fixa. A dimensão vertical e a aparência estética podem ser reconstruídas da forma desejada.



***PALAVRAS-CHAVES:*** ósseo-integração basal, carregamento imediato, prótese fixa


***BOIと固定補綴の上部構造による萎縮下顎の修復***


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***概要：***基底部で骨統合されたインプラントの即時装着法により、非着脱性の萎縮下顎修復が可能になった。固定橋義歯のための信頼性の高い基礎部分形成には、4つから5つのインプラントが必要である。この方法により、垂直方向の審美的に望ましい修復が実現できる。



***キーワード：***基底部骨統合、即時装着、固定補綴