Basal Implantology

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Foreword

Basal implantology is both an art and a science. Restoration of the lost dental organ must adequately fulfill the esthetic, phonetic, and functional requirements of the patient and last in a state immune to disease. Multidisciplinary research and clinical trials have played an essential role in the development of state-of-the-art implant systems that satisfy both professional needs and the public's demand for safe, effective therapy that is both affordable and as rapid as possible.

It has been our endeavor to present a sound application of proven principles, placing emphasis on the importance of familiarity with the biological, mechanical, and prosthetic aspects of basal implants and their supporting structures as revealed by analysis of more than three decades of clinical studies, research projects, and experimental investigations.

This manual is a guide to the practical application of biological and mechanical principles in the everyday practice of basal implantology and osseointegration (BIO concept), from single tooth replacements to full arch reconstructions. In particular, it provides an introduction to techniques to improve the future implant bed by activating the patient's own stem cells (application of bone matrix osseotensors several weeks before implant installation) and multicortical osseointegration obtained using specially designed maxillo-mandibular basal Diskimplants®. Used by leading restorative implantologists for more than 30 years, these well-established treatment modalities offer patients an attractive alternative to more invasive procedures. In desperate clinical situations, basal implantology can represent the last chance for an oral invalid to have fixed teeth once again and thus be able to pursue normal personal, professional, and social activities. However, basal implantology is also indicated in less complex cases. For partially edentulous patients with little available bone, laterally inserted Diskimplants® represent a safe and rapid solution. The same is true for patients reluctant to undergo a bone graft procedure when bone anatomy is too shallow or too thin to receive a root-form implant.

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Preface

Basal implantology has undergone tremendous growth in recent years correlated with multiple innovations, including the flat implant emergence profile, screw-secured plate-form Diskimplants®, micro-threaded tubero-pterygoid Fractal® implants, and bone matrix osseotensors. CAD/CAM technologies, 3D treatment planning, and digital workflow processes have all contributed to this progression.

As applied sciences, medicine and dentistry are a training ground. Regardless of the implant system selected, the clinician must be prepared both technically and psychologically to manage potential complications and failures. Unexpected reactions or events can occur at any time and surprise even the most experienced teams using the most reliable systems. Hands-on courses and training with mentors are thus essential to develop skill in this particular field.

Of course, more important than the brand of implant is the ability of the professional to make the correct diagnosis and establish an appropriate treatment plan, paying attention to anticipation of potential problems. This may even mean deciding not to use implantology at all. When implants are indicated, patients must be followed up over the long term so that any necessary preventive and curative actions can be taken. While this is no absolute guarantee against failure, it reduces the potential severity and consequences. Should a problem arise, effective solutions exist. For example, screw-retained prostheses on basal implants are easily retrieved. This facilitates verification of individual implants and makes correction of problems easier and less expensive.

Today, all well-trained surgical and prosthodontic teams can incorporate basal implantology in their implant practice to successfully perform oral rehabilitation without more invasive procedures. This book is written to help professionals in this way.

Having followed these simple rules over so many years, I can say that I still enjoy practicing basal implantology as it allows so many oral invalids to once again benefit from fixed teeth.

Nice, France — Gérard M. Scortecci

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Part I

Fundamental Basis

Principles of Basal Implantology

1

Gérard M. Scortecci, Carl E. Misch, and Guillaume Odin

1.1 Definition of Basal Implantology: Dynamic Dental Implant Classification

Endosseous dental implants can be categorized according to their shape, surface characteristics, chemical composition, or the manner in which they are inserted into the jaw. Based on their dynamic mode of insertion, all dental implant systems can be divided into one of two categories (Fig. 1.1):

Axially Inserted Crestal Dental Implants (Root-Forms, Blades, Mini-pins, etc.)

Osteotomy is initiated on the crest of the jaw and proceeds axially (downward in the mandible, upward in the maxilla). The one exception is staple implants. This category includes blades (vertical platform dental implants) and root-form dental implants such as screws and cylinders. The crestal approach allows the surgeon to insert the implant perpendicular to the crest or tilted, i.e., angulated with respect to the bone crest.

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Laterally Inserted Basal Dental Implants (Diskimplants®) (Figs. 1.2, 1.3, and 1.4)

Osteotomy is initiated apically on the basal bone of the buccal or lingual/palatal aspect of the jaw. The entire procedure is performed laterally, at the same initial depth. This category covers all types of Diskimplants® and their clones (cf. "Disk implant," ICOI glossary, 2017).

Basal Implantology

This term refers to the lateral insertion of disk-form implants into basal bone and, more generally, to the anchorage of implants in basal bone (e.g., root-form implants placed in the zygomatic and/or pterygoid process). The range of designs (single-, double-, and triple-disk implants, horizontal plate-form implants secured with osteosynthesis screws, etc.) allows management of the diversity of anatomic situations and bone qualities.

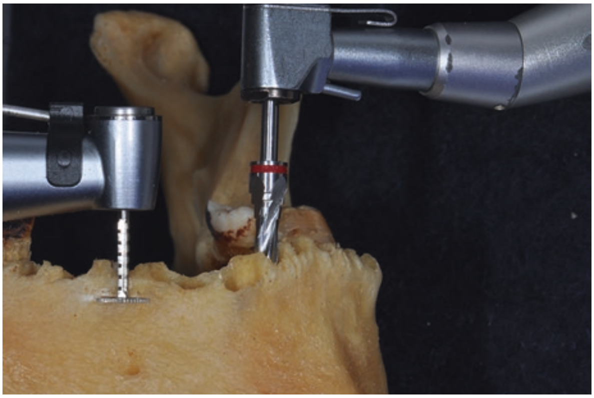


Fig. 1.1 Lateral osteotomy (basal implants) and crestal osteotomy (axial implants)

Fig. 1.2 Basal Diskimplant® inserted laterally above the mandibular canal

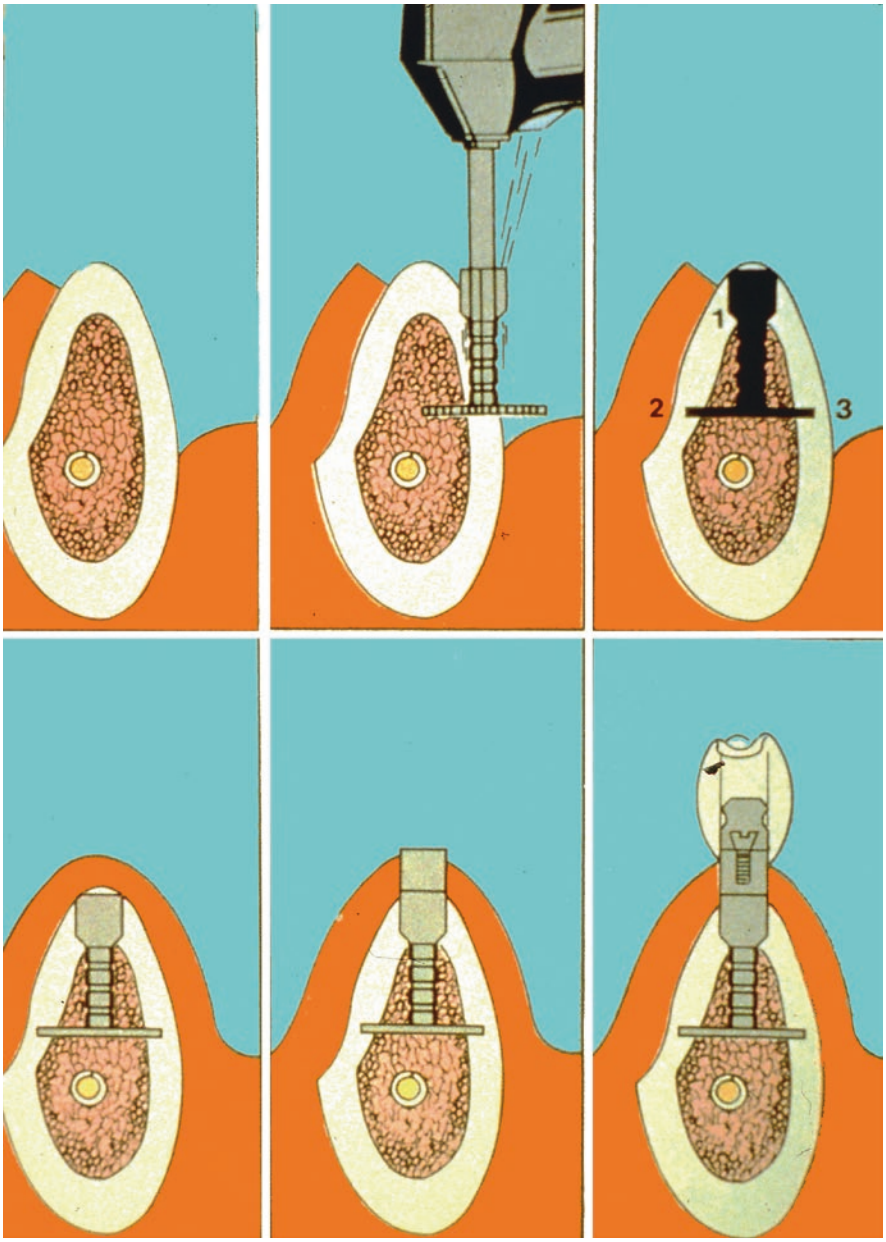


Fig. 1.3 Lateral osteotomy with a titanium cutter; full-thickness flap procedure (submerged protocol; waiting period 4–6 months)

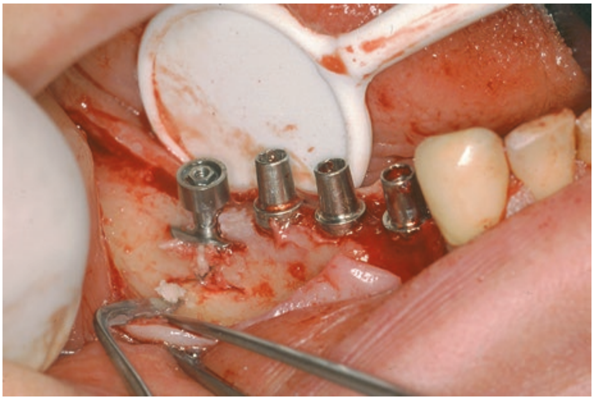


Fig. 1.4 Three root-form implants and one laterally inserted double Diskimplant® (7G2-DDM5) were installed to replace the two missing lower right molars and the missing lower right premolar (immediate loading protocol). The lateral osteotomy was filled in with autologous bone chips from the axial drilling procedure for the root-form implants

Diskimplants®

These laterally inserted basal dental implants are installed such that their wide apical base extends from the buccal cortical plate to the lingual or palatal cortical plate. The Diskimplant® design combines a horizontal platform (similar to blade implants) and a perpendicular cylindrical shaft (equivalent to a root-form dental implant). A specific titanium instrument, called a cutter, is utilized to prepare the "T-shaped" osteotomy. This unique tool "cuts" the bone horizontally and vertically at the same time. Diskimplants® were first presented at the International Congress of Oral Implantology in Munich, Germany on June 13, 1984. The BIO concept (Basal Implants and Osseointegration) was internationally developed at the First European BIO Forum in Paris on Nov. 29, 2001. Over the years, Diskimplants® have undergone various modifications (external threaded shaft, external hexagon, internal thread, Monobloc flat emergence profile, etc.). However, three features have remained unchanged: one-piece fabrication from titanium bars (i.e., true even for the large horizontal plateform Diskimplants®), a non-modified surface machined *ad modum Brånemark*, and use of one-piece T-shaped titanium cutters for lateral osteotomy.

1.2 Objectives of Basal Implantology

The main objective of basal implantology is restoration of the vital function and characteristic beauty of the masticatory apparatus in difficult or extremely difficult anatomic situations using a minimally invasive procedure based on rational application of biologic, anatomic, physiologic, and mechanical principles with respect of hygiene and esthetic requirements. Straightforward basal implant techniques are generally preferable to invasive high-risk procedures involving long waiting periods. A "root-form implant only" approach, for example, may require prior modification of the bone anatomy using grafting procedures before implant placement is feasible.

As oral implantology is not an emergency procedure, the only candidates for this prosthetically driven technique procedure are physically and mentally fit individuals, preferably non-smokers. Well-controlled ASA 1 to ASA 3 patients may also be suitable implant candidates. Along with general good health, satisfactory oral hygiene and absence of infection are essential.

Basal implants enlarge the scope of implant dentistry without requiring recourse to complex techniques such as distraction, bone splitting, grafting, etc. prior to implant installation. Of course, they can also be used in combination with more invasive procedures (sinus elevation, lateral displacement of the inferior alveolar nerve, calvarial bone graft, iliac bone graft, pedicled fibula bone graft, etc.). Root-form dental implants and basal Diskimplants® can be used separately or in association to provide stable and reliable support for fixed, implant-supported restorations. This is especially useful for immediate functional loading protocols (Figs. 1.5 and 1.6). Laterally inserted Diskimplants® are often indicated whenever root-form implants cannot be installed directly due to insufficient bone volume and/or quality, but they can also be placed in much larger bone volumes if so desired.

Basal implants are always placed in native living bone. Bone grafting and GBR may be performed at the time of installation in order to increase bone volume, but not to provide mechanical anchorage.

Fig. 1.5 Panoramic radiograph: atrophic posterior upper left maxilla

Fig. 1.6 Two monodisk Diskimplants® and a tubero-pterygoid root-form implant. Screw-secured, implant-supported fixed ceramic bridge. No sinus elevation was required

Diskimplants® are particularly indicated in the following cases:

- High, thin bone ridges less than 3 mm thick (Fig. 1.7). Technical reduction of such ridges is unnecessary because the osteotomy starts from the apical portion of the bony implant bed.
- Flat ridges with an available bone height of less than 5 mm (Figs. 1.8, 1.9, and 1.10).
- Extremely atrophic jaws, which can be directly managed with basal implants associated with guided bone regeneration (GBR) and immediately loaded with a highly rigid, screw-secured fixed prosthesis.

The various indications and contraindications for basal implants are developed in more detail in Chap. 6.

The surgeon, prosthodontist, and dental technician must all be trained in the fundamental concepts of basal implantology that differ in many aspects from those

Fig. 1.7 Laterally inserted Diskimplant® placed from the lingual aspect in a high knife ridge (bone thickness at crest level ≤2 mm)

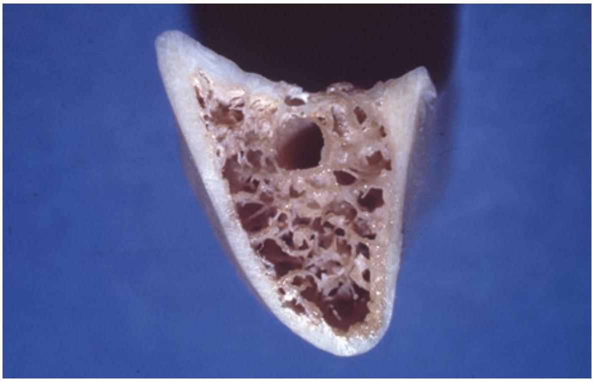


Fig. 1.8 Typical indication for basal implantology in an atrophic posterior mandible with less than 1.5 mm of bone height available above the mandibular nerve. The flat, wide ramus area is an indication for a horizontal plate-form Diskimplant®

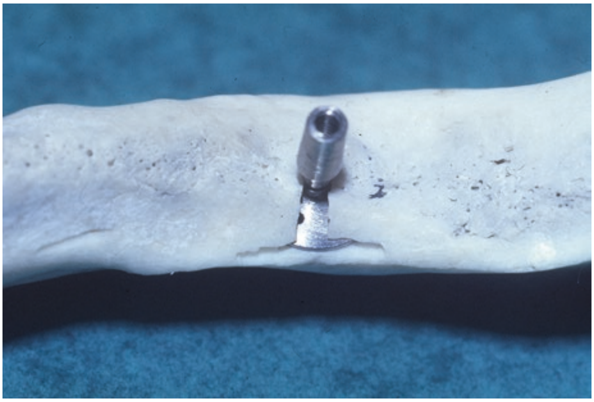


Fig. 1.9 Occlusal view of a posterior lateral osteotomy in a dry mandible at a bone depth of 1.5 mm (disk diameter 9 mm)

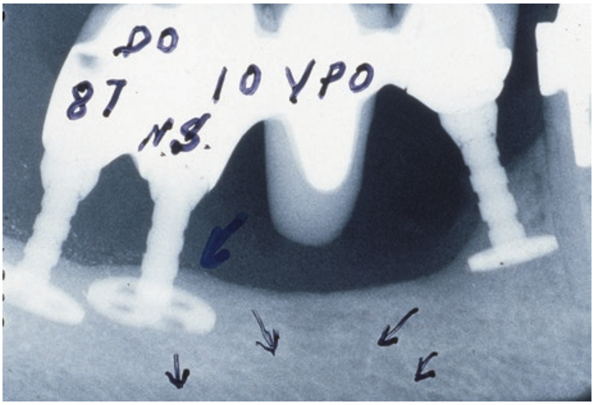


Fig. 1.10 Periapical radiograph after 10 years of function (initial bone height was less than 2 mm). No bone loss. Bone gain visible above the three Diskimplants®. After removal of a failing cobalt-chromium subperiosteal implant, the lateral osteotomy was performed starting on the lingual aspect of the mandible. The final cement-retained bridge was installed after 6 months (delayed loading protocol)

for root-form implants. Mastery of basal implant procedures, which require full-flap elevation, involves a progressive learning curve that is longer than for root-form implants; continual practice and close collaboration with a dental laboratory familiar with the technique are paramount. The surgeon must be familiar with maxillofacial surgical anatomy and be trained in sinus elevation procedures and intraoral bone grafting. Immediate loading protocols for rehabilitation of completely edentulous arches require both surgical skills and prosthodontic expertise; in particular, the surgical team must be able to take the impression and register primary inter-arch occlusion in the operating room at completion of surgery.

1.3 Basic Principles of Basal Implantology

No superstructure can be more enduring than its foundation. Occlusal stress and foundation resistance are reciprocal forces which must be properly balanced to obtain durable functional efficacy. The long-term function of an osseointegrated, cortically anchored basal implant restoration requires establishment of an active bond between the tissues and the Diskimplant®. Thanks to an osseo-adaptative process, the multicortical basal implant is incorporated into the hard and soft tissues, which gradually adapt to their new function through the remodeling process.

Creation and maintenance of this structural and functional bond between biological and non-biological materials mandate precision during the various stages of treatment plus respect of basic principles:

- Adequate treatment planning and presurgical bone matrix activation of the future implant bed with osseotensors to promote stem cell recruitment and improve the blood supply
- Use of an aseptic protocol to avoid contamination and infection of the implant site
- Preservation of the peri-implant blood supply by atraumatic handling of the soft tissues, especially the periosteum, during full-thickness flap elevation and use of a lateral osteotomy procedure under copious irrigation to prevent thermal injury
- Achievement of multicortical support providing absolute primary implant stability in dense living native bone (including pedicular grafts such as fibula grafts), not in bone substitute material or a free bone graft

Respect of Bone Biology: The Importance of Initial Osteogenic Activation

The future recipient bone bed should be activated prior to implant placement using a bone matrix osseotensor in order to reinforce the local blood supply, stimulate bone cell growth, and improve initial bone quality for better osseointegration of the intended basal implant (see Chap. 5 for more details).

Care must be taken not to contaminate the super-clean surface of the basal implant to allow establishment of a reliable primary biological bond and to avoid the risk of peri-implantitis in the future by limiting metal release during mastication. Finally, the body of the basal implant should never be in direct contact with the soft tissues; autologous bone grafts, bone substitute material, and PRF should be used to completely cover any protruding titanium surfaces.

Multicortical Anchorage and Long-Lasting Primary Stability

The wide horizontal platform of the basal implant (disk or other horizontal design) must be installed with multicortical anchorage because absolute primary stability is essential to obtain osseointegration that is maintained over time. The design and dimensions of the implant must permit the connection of prosthetic components in a functionally useful manner to create a fixed prosthesis. The occlusal forces transmitted via the future prosthesis must be properly distributed so as not to exceed the breaking point of the bone and the prosthetic components.

In extremely atrophic jaws, multicortical anchorage of extra-maxillary and extra-mandibular plate-form Diskimplants® using orthopedic screws placed in the major skeletal pillars of the jaws ensures functional stability during mastication over the long term (Figs. 1.11, 1.12, and 1.13).

In high knife ridges (crestal bucco-palatal bone thickness <2 mm), double- or triple-disk basal Diskimplants® can serve as scaffolding for bone substitute material and PRF membranes to increase bone volume at the implant site by guided bone regeneration (GBR) (Figs. 1.14 and 1.15). Thin ridges of this type are not suitable for horizontal plate-form Diskimplants®, which require a wide, flat bone bed for correct installation. Primary basal implant stability is mandatory in both situations.

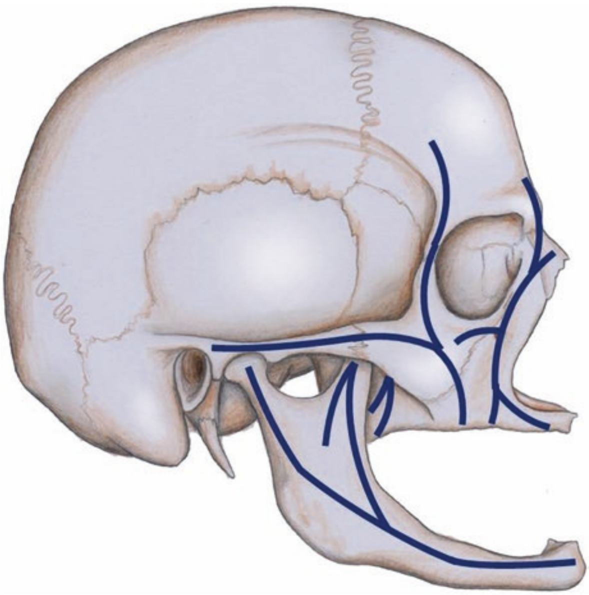


Fig. 1.11 Basal bone in an atrophic jaw; the alveolar bone has completely disappeared. The blue lines show the main bony buttresses for reliable anchorage of basal implants in the maxilla and the mandible

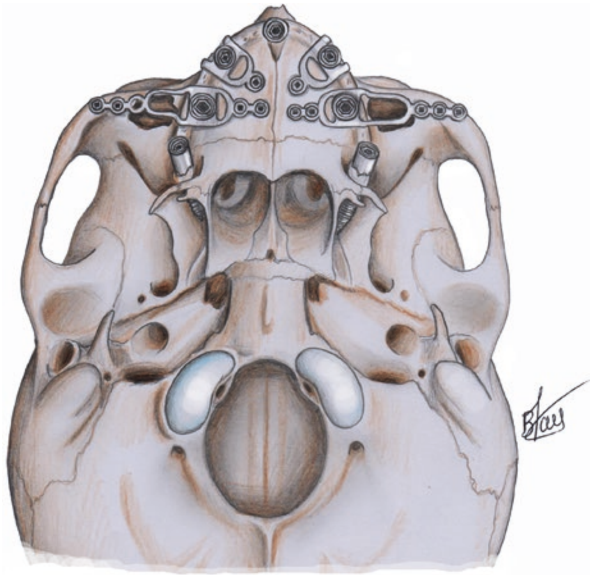


Fig. 1.12 The main areas for installation of horizontal plate-form Diskimplants® in the maxilla. Zygomatic Diskimplants® can be installed such that they span lateral openings in the sinus wall; absolute stability is obtained by firmly screwing them onto the dense malar and palatal bone. They must then be covered by bone substitute material and PRF. Strong distal anchorage is achieved in the tubero-pterygoid area with microthreaded root-form Fractal® implants

Fig. 1.13 The ramus area offers dense bone for placement of horizontal plate-form Diskimplants®. Sharp crestal soft tissue incisions should be made until the scalpel reaches the bone crest. The plate-form Diskimplant® must fit passively into the bony site prepared by the titanium cutter and is stabilized by mini orthopedic screws (4–6 mm in length). The same technique is used for the canine and zygomatic areas of the upper jaw. A screw-secured, fixed maxillary prosthesis acts as an external orthopedic fixator for the implants. All extra-mandibular portions of the basal implant must be fully covered by bone substitute material (Bio-Oss®, CoreBone®, Dentin Grinder graft, Ivory®, etc.) and PRF membranes before closing the full-thickness flap

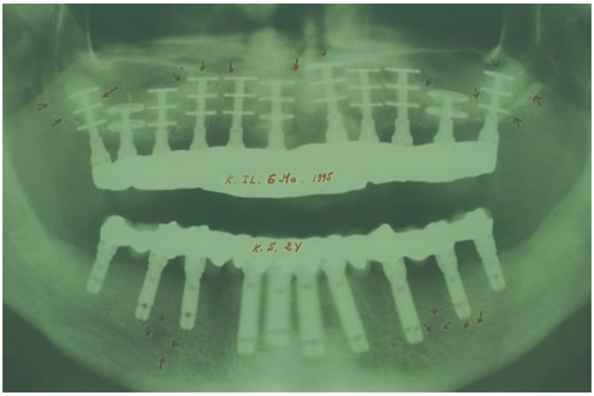
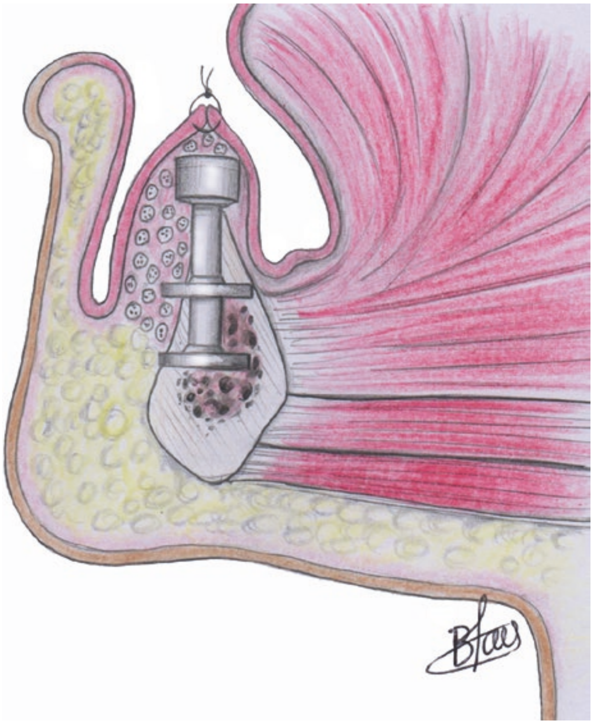


Fig. 1.14 Full-mouth rehabilitation: high maxillary knife ridge (bucco-palatal width <2 mm at crest level) managed with double and triple Diskimplants®. The protruding disk base is covered by bone substitute material for GBR (immediate functional loading protocol). Horizontal plate-form Diskimplants® are not indicated in this anatomic situation. Root-form implants can be installed in the mandible depending on available bone volume and quality

Fig. 1.15 The protruding portion of the Diskimplant® is used as scaffolding for GBR (tent effect) with bone substitute material and PRF (submerged technique for single-tooth replacements) in mandibular knife ridges



Implant Loading Protocols

Loading protocols vary as a function of the clinical situation:

- Immediate loading of full-arch restorations is possible using a highly rigid, fixed prosthesis that is screw-secured to basal implants with a flat emergence profile (Monobloc emergence).
- Delayed loading of basal implants is recommended for implant management of partial edentulism and single-tooth replacements with difficult occlusal conditions.

Biomechanical, surgical, and prosthetic requirements mandate close collaboration between the surgeon, prosthodontist, and dental laboratory. Passive fit of the final prosthesis is critical for satisfactory mastication and speech. Use of a transitional prosthesis for a period of time allows verification that functional and cosmetic requirements are met.

Maintenance and Follow-Up

3D imaging investigations are necessary for assessment of any biological or mechanical complications at an early stage. The radiological images around the base of a Diskimplant® must always be correlated with clinical findings as they can differ from those seen with conventional root-form implants. For example, minimal radiolucency around the base of a disk without any pain or mobility does not mandate removal. Implant mobility associated with pain, however, is cause for implant removal. Awareness of these differences can prevent unnecessary removal of what is actually a well-integrated implant.

Appropriate maintenance (plaque control) and atraumatic, well-balanced occlusion is essential for long-term success. The gingiva surrounding prosthetic abutments and implant emergences must be kept in a clinically healthy state by appropriate peri-implant soft tissue management and local hygiene. Revision and correction of complications, when necessary, can be achieved in a minimally invasive manner thanks to the easy retrievability of screw-secured, bone-anchored prostheses.

Anticipation of potential problems is also an important factor for the long-term success of basal implant-supported restorations. The knowledge and experience needed to satisfy these requirements cannot be improvised nor can they be acquired without appropriate theoretical and practical training. Coordinated treatment planning, precise execution, careful follow-up, and maintenance over time are the keys to successful, long-lasting fixed basal implant-supported rehabilitations.

1.4 Divisions of Available Bone Anatomy and Bone Density

Divisions of Available Bone (Figs. 1.16, 1.17, 1.18, and 1.19)

Long-term success in implant dentistry requires the evaluation of more than 50 dental criteria, many of which are unique to this discipline [1]. The training and

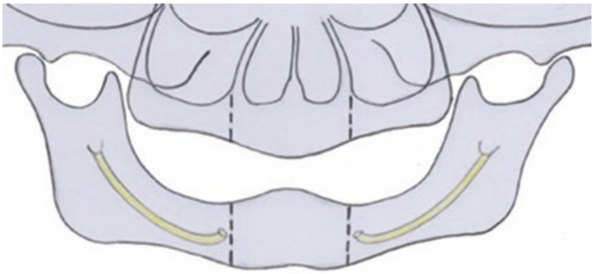


Fig. 1.16 Division A: there is sufficient bone volume for root-form implants. However, volume alone is not sufficient; bone density is more important. In case of low density, even with sufficient volume, it is safer to use basal implants with anchorage of the wide base in the cortical plates

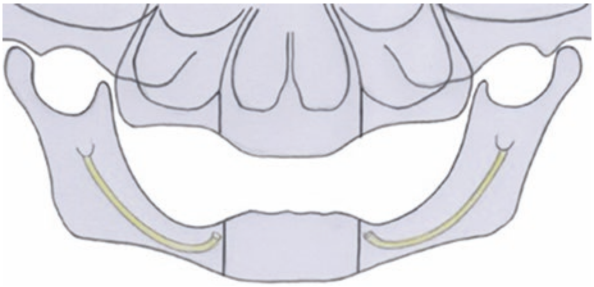


Fig. 1.17 Division B: sufficient bone volume for root-form implants (short implants in the posterior area, sinus elevation, or short implants in the posterior maxilla) or basal implants. Here, again, bone density is more important, and it is safer to place basal implants if low-density bone is detected

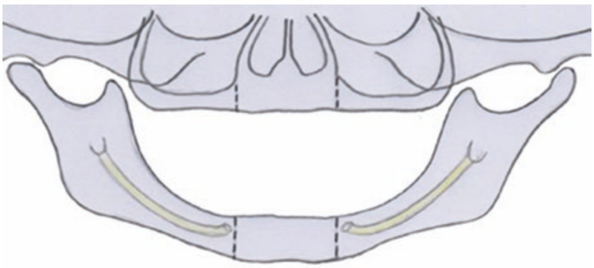


Fig. 1.18 Division C: insufficient bone volume in the posterior sectors (maxilla and mandible). Root-form implants combined with prior bone grafting and/or GBR or basal implantology are indicated

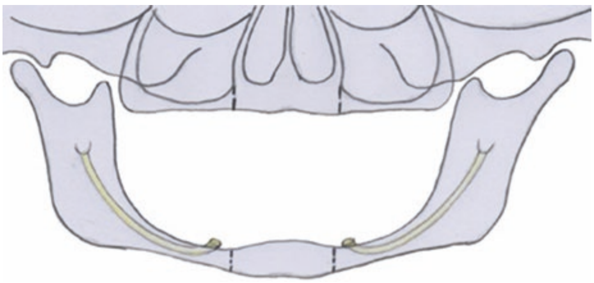


Fig. 1.19 Division D: skeletal basal bone. This situation can be managed either immediately, by basal implantology, or by performing an autologous extraoral bone graft procedure prior to implant placement

experience of the doctor and the volume, density, and shape of the available bone are primary determinants of success for an individual patient. The Misch/Judy classification of available bone (Divisions A, B, C, and D) follows the natural patterns of bone resorption in the jaws. Each division is associated with unique surgical and prosthetic approaches.

Division D (Deficient Bone)

The completely edentulous Division D patient is the most difficult to treat in implant dentistry. Benefits must be weighed carefully against the risks. Although the practitioner and patient often regard this condition as the most dramatic possible, these patients do not usually have oral antral fistulae or deviated facial features prior to treatment. If implant failure occurs, the patient may become a dental cripple, unable to wear any prosthesis. Treatment of the Division D arch requires more training and results in more frequent complications related to grafting, early implant failure, and soft tissue management. Treatment options thus include a more guarded prognosis. When physical and psychological general health, smoking habits, and occlusal conditions are aggravating factors, a wise and safe decision is to not install implants (not even basal implants) and to maintain the patient with a conventional denture. The prudent solution is to educate the patient about the risks of his or her situation when proposing basal implantology and GBR after initial osteogenic preparation with bone matrix osseotensors. The choice to render treatment is the doctor's, not the patient's. Initial bone support must not be compromised if implant failure could result in significantly greater risks.

1.5 Alveolar Bone and Basal Bone (Figs. 1.20 and 1.21)

Characteristic of human jaws, these complementary bony structures are correlated with the presence or the absence of teeth and their periodontal apparatus.

Alveolar Bone

This highly differentiated bony structure is "born with the tooth, develops and functions with the tooth, and progressively disappears after tooth loss." The alveolar bone lies above the basal bone, without any visible anatomical landmarks. Alveolar bone is connected to the teeth by means of the periodontal ligament that has a dense blood supply, lymph vessels, and nerves. The periodontal ligament and related fluids represent a shock-absorbing mechano-hydraulic system. This sophisticated apparatus is also the pathway for the mechanoreceptors involved in proprioception and directly connected to the brain via the trigeminal nerve. Alveolar bone can progressively disappear as the result of periodontal disease, tooth extraction, or trauma and can be drastically reduced in cases of agenesis. Alveolar bone is also capable of

Fig. 1.20 D3 bone is very common in the maxilla. In this situation, a root-form implant can easily be installed in the palatal aspect immediately after extraction of the second upper premolar. If the buccal plate is absent, a double-disk asymmetric Diskimplant® (7 × 5 mm) must be inserted laterally and covered by bone substitute material and PRF membrane (delayed loading 6–7 months)

following the tooth pathway during orthodontic movements, whereas an osseointegrated implant directly anchored in bone remains in place and does not move.

Basal Bone

The skeletal bone that remains after tooth loss and complete resorption of the alveolar crest is termed basal bone. This bone structure has a very low turnover (ten times less than alveolar bone) and is highly sensitive to thermal injury and infection. Besides reduced bone volume and extreme differences in density depending on the sector (D1 in the mandibular mental area versus D4 in the posterior maxilla), basal bone has a limited blood supply. In atrophic jaws, for example, the main source of blood is the inner layer of the periosteum. This explains why maintenance of aseptic conditions during surgery, careful handling of the periosteum, profuse saline irrigation during lateral osteotomy, and primary stability are of paramount importance for bone healing after basal implant installation.

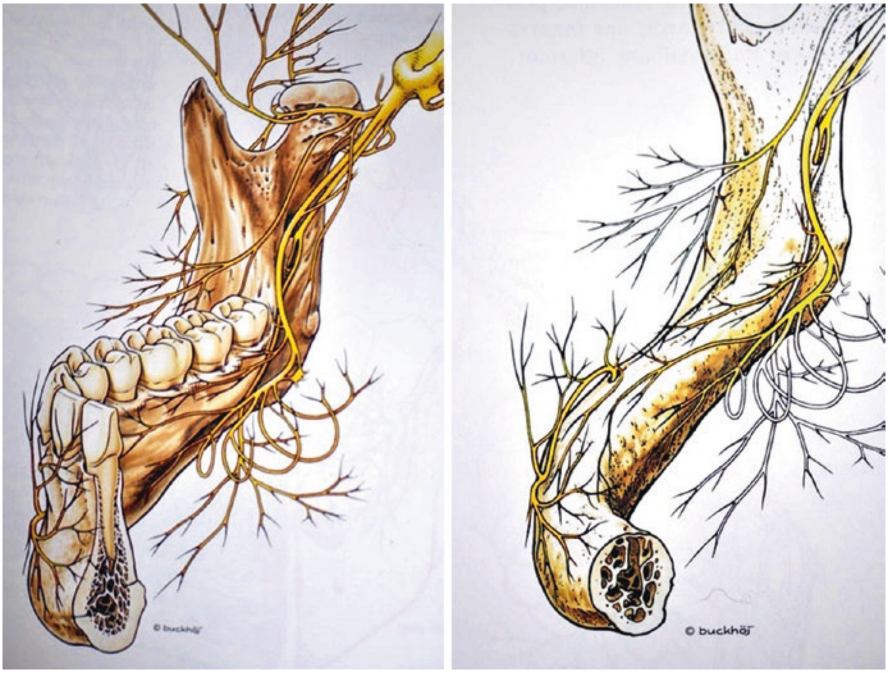


Fig. 1.21 Comparison of alveolar bone and basal bone (from Evers and Haegerstam, 1982)

1.6 Bone Density

Particularly important in implant dentistry, "available bone" describes the external architecture or volume of the edentulous area considered for implants. The internal structure of bone is described in terms of quality or density, which reflect its strength. As stated by Wolff [2]: "Every change in the form and function of bone or of its function alone is followed by certain definite changes in the internal architecture, and equally definite alteration in its external conformation, in accordance with mathematical laws." Bone density may be determined preoperatively by tactile sense using a manual osseotensor, by tactile determination during osteotomy, or, more accurately, by CT scans.

Clinical Evidence Highlighting the Influence of Bone Density on Implantation Success Rates

The anterior mandible has greater bone density than the anterior maxilla. The posterior mandible has poorer bone density than the anterior mandible. The poorest bone quality in the oral environment typically exists in the posterior maxilla and is associated with high failure rates. Jaffin and Berman [3] reported a 44% failure rate when poor density was observed in the maxilla, with the majority of failures noted after second-stage surgery. Of all implant failures in their study sample, 55% occurred in soft bone. The group documented a 35% implant loss in all regions of the mouth when bone density was poor. Engquist et al. [30] also reported a high percentage of clinical failures (78%) in soft bone types.

The Misch Bone Density Classification

The degree of crestal bone loss has also been related to stress and bone density. In 1988, Misch defined four bone density groups independent of the regions of the jaws, based upon macroscopic cortical and trabecular bone characteristics. The regions of the jaws with similar densities were often consistent. A suggested implant design, surgical protocol, healing, treatment plans, and progressive loading time spans have been described for each bone density type. Following this regimen, similar implant survival rates are observed for all bone densities.

The Misch bone density classifications are shown in Tables 1.1 and 1.2. Dense and/or porous cortical bone are found on the outer surfaces of bone and include the crest of an edentulous ridge. Coarse and fine trabecular bone are found within the outer shell of cortical bone and occasionally on the crestal surface of an edentulous residual ridge. These four macroscopic types of bone may be arranged from the densest to the least dense:

1. Dense cortical (Fig. 1.22)
2. Porous cortical (Fig. 1.23)
3. Coarse trabecular (Fig. 1.24)
4. Fine trabecular (Fig. 1.25)

Table 1.1 Misch/Scortecci bone density classification

	Description of bone
D1 bone	Dense cortical bone with very little spongiosa within
D2 bone	Thick dense cortical bone plate and coarse trabecular bone within
D3 bone	Thin cortical bone plate and fine trabecular bone within
D4 bone	Fatty trabecular bone with no cortex
D5 bone	Immature, non-mineralized bone

Table 1.2 Usual anatomic location of bone density types (% occurrence)

	Bone site			
Classification	Anterior maxilla	Posterior	Anterior mandible	Posterior
D1 bone	0	0	8	2
D2 bone	45	5	67	51
D3 bone	65	50	25	46
D4 bone	5	45	0	1

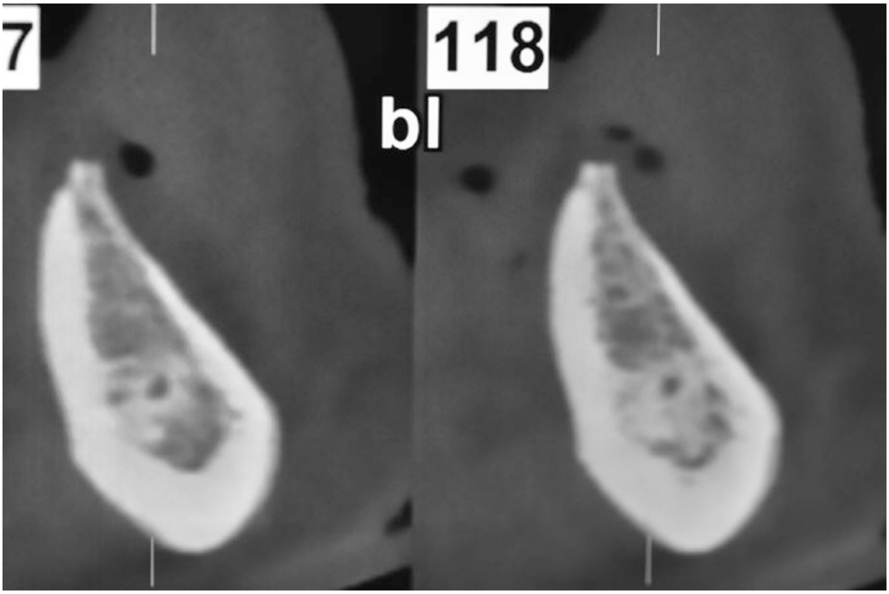
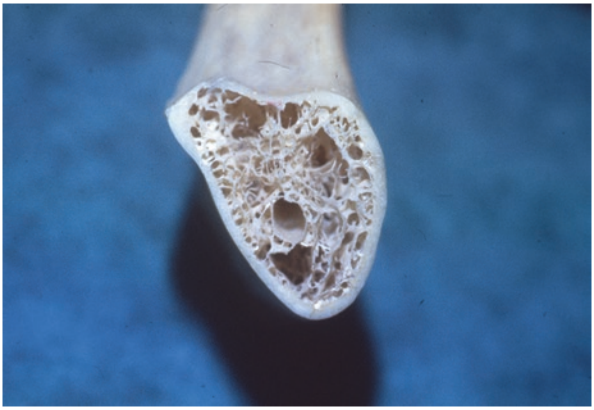


Fig. 1.22 D2 thick cortical bone plate and porous spongiosa

Fig. 1.23 D3 coarse trabecular bone and thin cortical plate



These four macroscopic densities describe and, in combination, establish four categories of bone located in the edentulous areas of the maxilla and mandible. The regional locations of the different densities of cortical bone are more consistent than the locations of trabecular bone, which are highly variable.

The macroscopic description of Misch bone density classification D1 bone is primarily dense cortical bone. D2 bone has dense to thick porous cortical bone on the crest and coarse trabecular bone within. D3 has a thinner porous cortical crest and fine trabecular bone. D4 bone has almost no crestal cortical bone. Almost all of

Fig. 1.24 Extraction of the maxillary molars may result in creation of an oro-antral communication. Socket preservation with a bone substitute material is mandatory

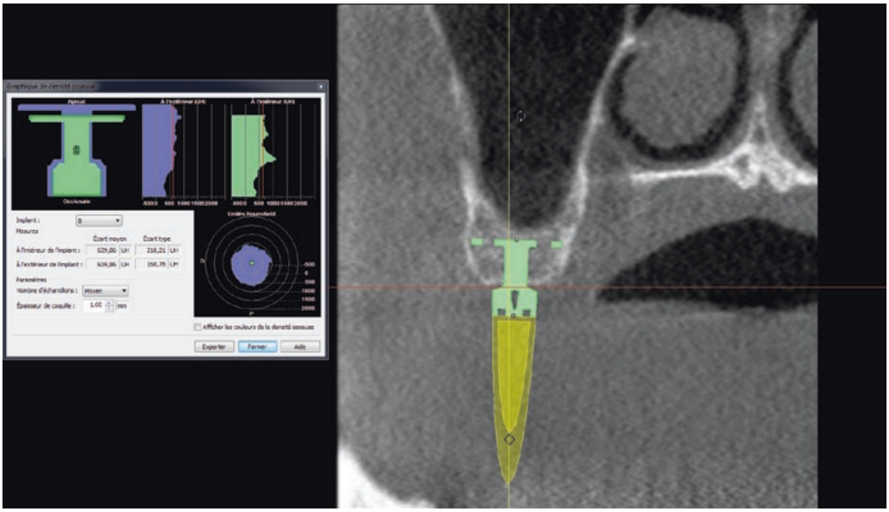


Fig. 1.25 Simulation of a 9-mm-diameter monodisk Diskimplant® placed beneath the sinus; the disk base extends from one cortical plate to the other

the total volume of bone next to the implant is composed of fine trabecular bone. A very soft bone, with incomplete mineralization, may be addressed as D5 bone. This description is usually of immature bone.

Bone Density Determined by Tactile Sense

In order to communicate broadly to the profession relative to the tactile sense of different bone densities, this classification is compared with materials of varying densities. Drilling and placing implants into D1 bone is similar to drilling into oak or maple wood. D2 bone is similar to the tactile sensation of drilling into white pine or spruce. Balsa wood is similar to drilling into D3 bone, and D4 bone is similar to drilling into Styrofoam™. Perception of bone density is similar with manual and rotary osseotensors.

Bone Density by Location

A review of the literature, blended with a post-surgery survey of 200 consecutive completely and partially edentulous patients, found that the location of different bone densities may be superimposed with the different regions of the mouth. D1 bone is almost never observed in the maxilla but may be found in the pterygoid process and the zygoma. In the mandible, D1 bone is observed approximately 8% of the time. D1 bone is observed four times as often in the anterior mandible compared with the posterior mandible (8% versus 2%). As the bone is reduced in volume, especially in the anterior mandible, D1 bone will occur with greater frequency and may reach 25%, whereas D3 will be less and be reduced to under 10%. The edentulous mandible often exhibits an increase in torsion and/or flexure in the anterior segment between the foramina during function. This increased strain causes the bone to increase in density.

Bone density D1 may be encountered in the anterior Division A mandible of a Kennedy Class IV partially edentulous patient with a history of parafunction and recent extractions. It may also be observed when angulation of an anterior implant requires the engagement of the lingual cortical plate in a Division A bone volume.

Bone density D2 is the most common bone density observed in the mandible. The anterior mandible consists of D2 bone two-thirds of the time. More than one-half of patients have D2 bone in the posterior mandible. In the maxilla, D2 bone is found less often than in the mandible. Approximately one-quarter of patients have D2 bone, and this is more likely in the partially edentulous patient's anterior and premolar region rather than in completely edentulous posterior molar areas. Single-tooth or two-tooth partially edentulous spans almost always have D2 bone.

Bone density D3 is very common in the maxilla (Fig. 1.26). More than one-half of patients have D3 bone in the upper arch. The anterior maxilla has D3 bone about 65% of the time, while almost one-half of patients have posterior maxillae with D3 bone (more often in the premolar region). Almost one-half of posterior mandibles also present with D3 bone, whereas approximately 25% of anterior edentulous mandibles have D3 bone.

The softest bone, D4 (Fig. 1.27), is most often found in posterior maxillae (approximately 60%), especially in the molar regions or after a sinus graft augmentation (where almost two-thirds of patients have D4 bone). The anterior maxilla has D4 bone less than 10% of the time, more often after an onlay iliac crest bone graft. The mandible presents with D4 bone in less than 3% of patients. When observed, it is usually Division A bone in a long-term, completely edentulous patient after an osteoplasty removes the crestal bone.

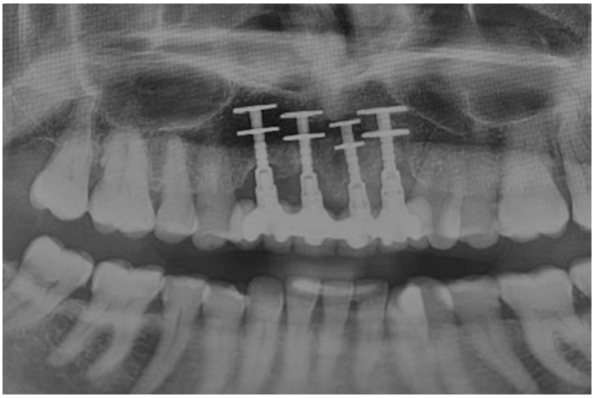
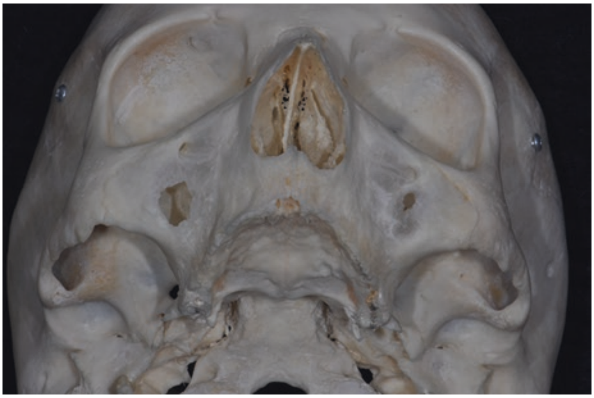


Fig. 1.26 D3 bone in the anterior maxilla. Severe facial trauma resulted in loss of the six upper front teeth along with their anterior buccal plate, leaving a high knife bone ridge. Four double-disk Diskimplants® were placed in 1985. The panoramic radiograph taken in 2016 shows these implants that are still in service after 31 years with no signs of peri-implantitis. A bone gain is visible in many areas

Fig. 1.27 D4 bone in the posterior maxilla



Generalizations for treatment planning can be made prudently, based on location. It is safer to begin by planning for less-dense bone so that the prosthesis is designed with slightly more, rather than less, support. The anterior maxilla is usually treated as D3 bone, the posterior maxilla as D4 bone, the anterior mandible as D2 bone, and the posterior mandible as D3 bone. Bone bed preparation with osseotensors prior to implant installation can dramatically improve initial bone density (see Chap. 5). The use of rotary osseotensors in D1 and D2 bone transforms the bone to active D2 status (i.e., D2 bone with active new bone cells and new blood supply [see Chap. 4]); an 8- to 15-day waiting period must be respected before proceeding with implant installation. Use of manual osseotensors in D3 and D4 bone promotes transformation to active D2 status but requires a longer waiting period (45–60 days) prior to surgery.

Radiographic Bone Density and 3D Anatomic Shape
(Figs. 1.28 and 1.29)

Periapical or panoramic radiographs are not helpful for determining bone density because the lateral cortical plates often obscure trabecular bone density and bone shape. Furthermore, such radiographs cannot quantify the subtle changes of D2 to

Fig. 1.28 The panoramic view gives the illusion that there is sufficient bone volume

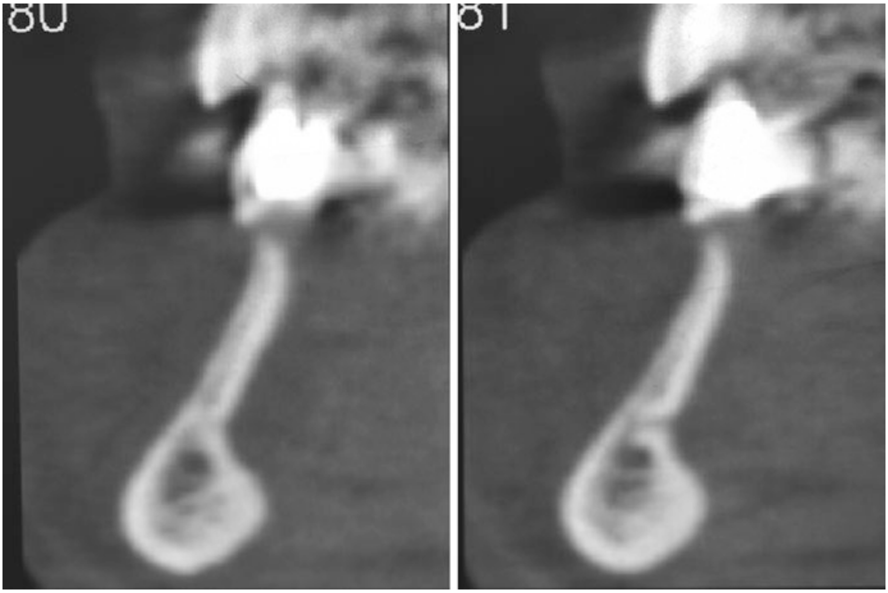


Fig. 1.29 Cone beam CT showing the considerable discrepancy between panoramic radiographs and cone beam CT: high knife ridge with a thickness of less than 3 mm but a bone height of more than 13 mm. Typical high knife ridge (D1 bone) suitable for double Diskimplants®. The remaining natural teeth are maintained by just a thin shell of alveolar bone. Extraction of natural teeth is particularly challenging because as much surrounding bone as possible must be preserved

D3 bone. Bone density and bone anatomy may be determined more precisely using tomographic radiographs, especially computerized tomograms (CT) and cone beam CT. Computed tomography produces axial images of the patient's anatomy, perpendicular to the long axis of the body. In general, the higher the CT number, the denser the tissue. Modern CT scanners and cone beam CT units can resolve objects less than 0.5 mm apart. The Misch bone density classification may be evaluated on CT images by correlation to a range of Hounsfield units: D1 corresponds to values greater than 1250 HU, D2 to 850–1250 HU, D3 to 350–850 HU, D4 less than 150–350 HU, and D5 bone less than 150 HU. The very soft bone observed after some bone grafts may be 100–300 HU.

Bone density is determined clinically using CT determination, as follows:

D1: >1250 Hounsfield units
D2: 850–1250 Hounsfield units
D3: 350–850 Hounsfield units
D4: <350 Hounsfield units

Evaluation of Bone Density During Lifetime

Bone density and bone anatomy (Fig. 1.30) are implant treatment plan modifiers in several ways: they influence not only pre-surgery bone management, selection of root-form and/or basal implants, implant dimensions, design, surface condition, number, the implant loading protocol, but also prosthetic choices (Figs. 1.31, 1.32, and 1.33). Consideration must be paid to the hormonal changes that occur in postmenopausal patients as considerable decreases in bone density can occur rapidly starting around the ages of 49–53 years. This is why multiple sites of initial cortical implant anchorage are so important.

A decrease in bone density is accompanied by a decrease in the strength of the bone. Reduction of the incidence of microfractures requires reduction of the strain

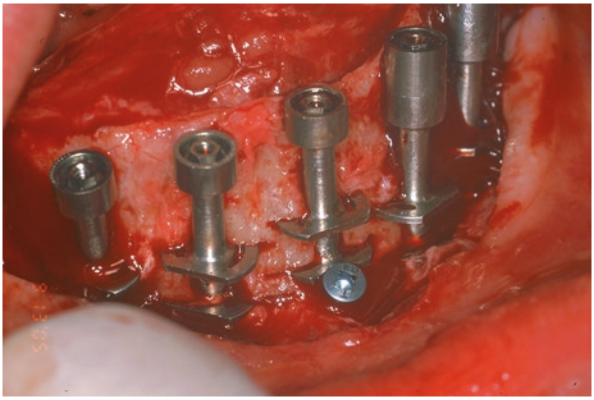


Fig. 1.30 After tooth loss, the residual high knife ridge (buccal-lingual width <2 mm) is managed with double-disk Diskimplants®. The protruding disk base is then covered with bone substitute material and PRF (immediate loading protocol). Mini orthopedic screws are placed at the base of the disk in order to guarantee primary stability

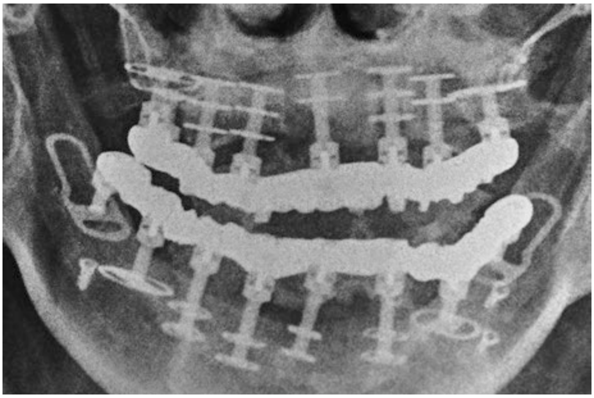


Fig. 1.31 Full-mouth rehabilitation with basal implants (immediate loading 48 h post-op): this patient suffered multiple maxillary and mandibular fractures in an automobile accident (panoramic view after 13 years of function)

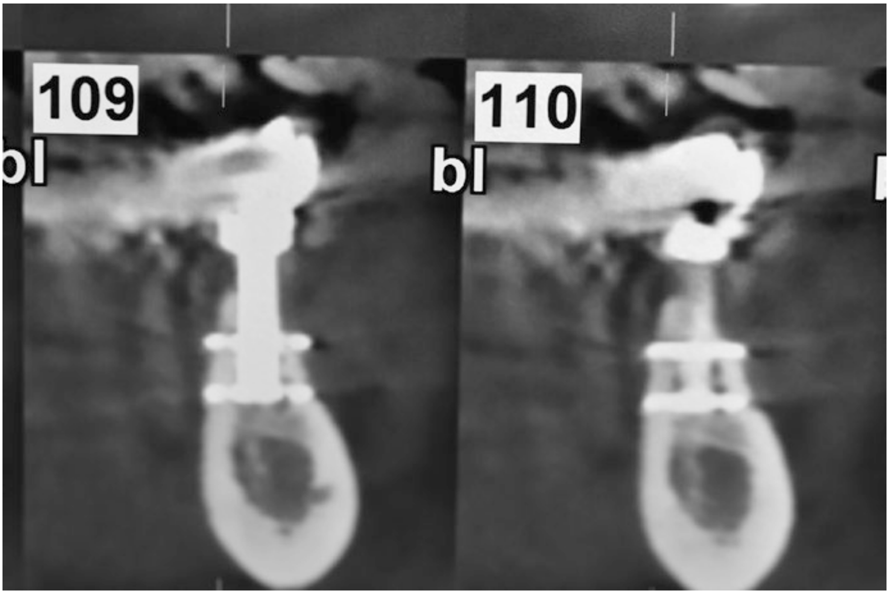


Fig. 1.32 Multicortical anchorage of double Diskimplants® above the mandibular nerve in a high knife ridge (D1 bone) after 13 years of function (same patient as Fig. 1.30)

applied to the bone. As strain is directly related to stress, the stress placed on the implant system should also be reduced as the bone density decreases. Stress is equal to the force divided by the functional area over which it is applied, such that $S = F/A$.

One way that biomechanical loads on implants may be reduced is by prosthesis design. For example, cantilever length may be shortened or eliminated, narrower occlusal tables designed and offset loads minimized, all of which reduce the amount of load. Night guards and acrylic occlusal surfaces distribute and dissipate

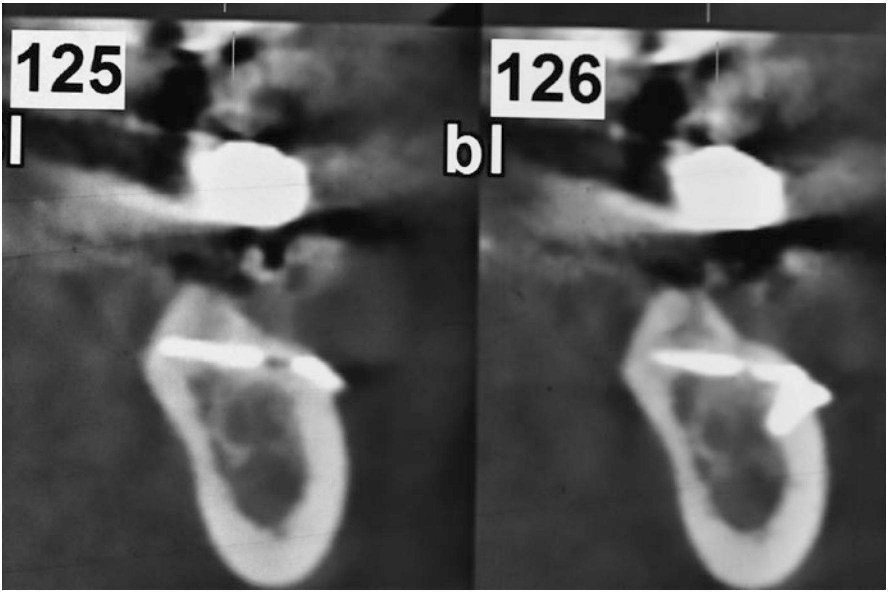


Fig. 1.33 Tricortical support of a 9-mm monodisk Diskimplant® placed 2 mm above the mandibular nerve in the flat bone ridge of this atrophic mandible (same patient as Figs. 1.37 and 1.38). A buccal orthopedic screw was placed at the base of the Diskimplant® to increase initial stability

parafunctional forces on an implant system. As the bone density decreases, these prosthetic factors become more important.

Stress may also be reduced by increasing the functional area over which the force is applied. Increasing the number of basal implants is an excellent way to reduce stress by increasing the functional loading area.

The width of the base of a Diskimplant® firmly anchored in the buccal and palatal or lingual cortical bone plate decreases stress by increasing the surface area. For every 0.5 mm increase in width, the surface area increases between 10% and 15%. Wider basal implants should be used in D4 bone compared with D1 or D2 bone.

Progressive Bone Loading

Progressive bone loading provides for a gradual increase in occlusal loads, separated by a time interval to allow the bone to accommodate. The softer the bone, the more important progressive loading. This can be achieved with a highly rigid CoCr/titanium/acrylic resin restoration screw-secured to basal implants instead of a ceramic bridge.

1.7 Surgical Anatomy Considerations (Figs. 1.34, 1.35, 1.36, 1.37, 1.38, and 1.39)

Basal implantology is applicable in a variety of clinical situations, from single-tooth replacement to full arch reconstructions. Even for oral invalids with moderately or severely atrophic jaws, the technique represents a unique means to restore fixed teeth without painful, time-consuming, expensive, and invasive preimplant bone grafting.

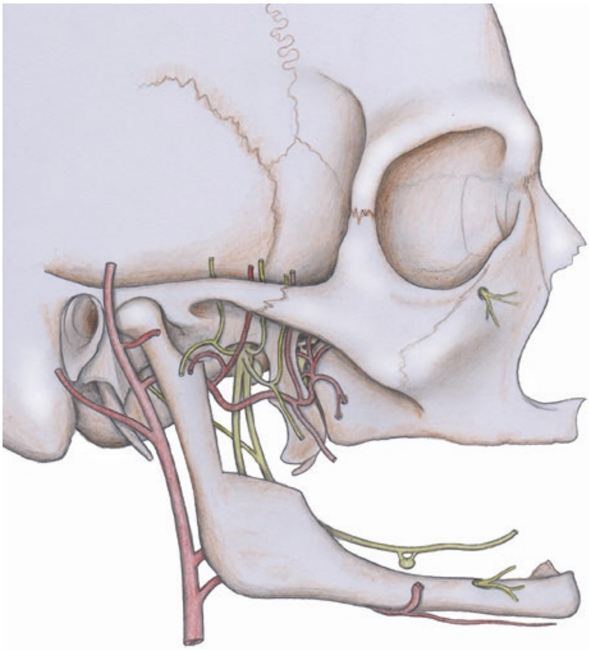


Fig. 1.34 Important anatomic landmarks: surgical anatomy showing critical areas to be avoided– Mandible: lingual and mandibular nerves and the submental artery– Maxilla and tubero-pterygoid area: maxillary artery and infraorbital nerve

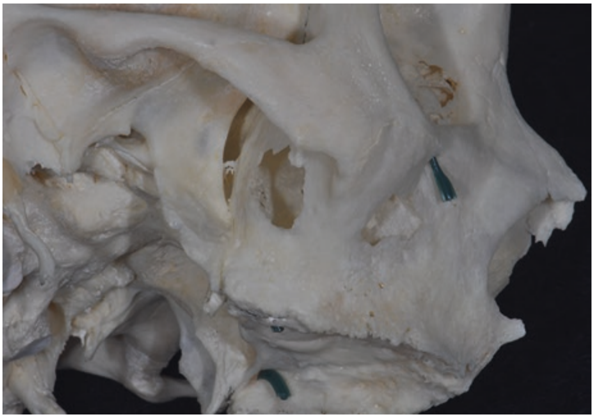


Fig. 1.35 Maxillary sinus area: very soft bone, if any ("eggshell-thin" bone). Use of a bone matrix osseotensor is mandatory (cf. Chap. 4)

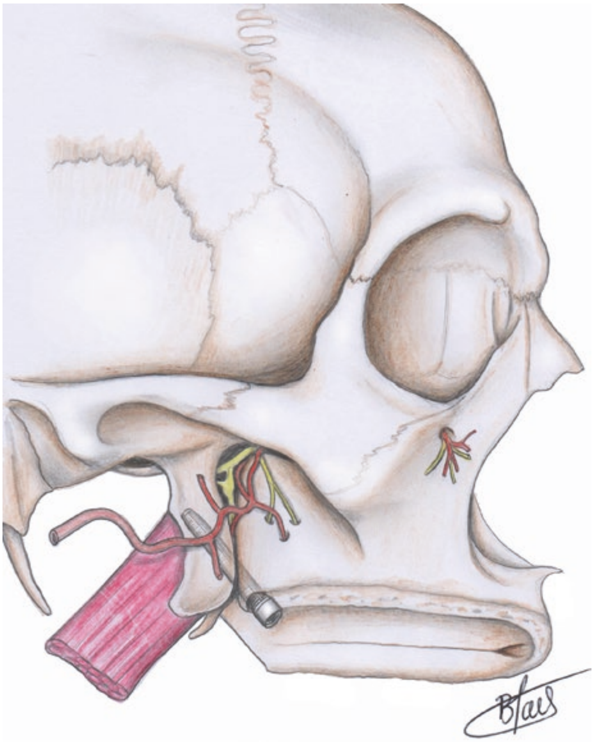


Fig. 1.36 Maxilla: the dense bones of the nasal floor, zygoma, and canine pillar area are suitable for basal implants screw-secured with osteosynthesis screws (length 4, 5 or 6 mm). Lateral view of the tubero-pterygoid area: this long root-form implant engages the dense bone of the pterygoid process

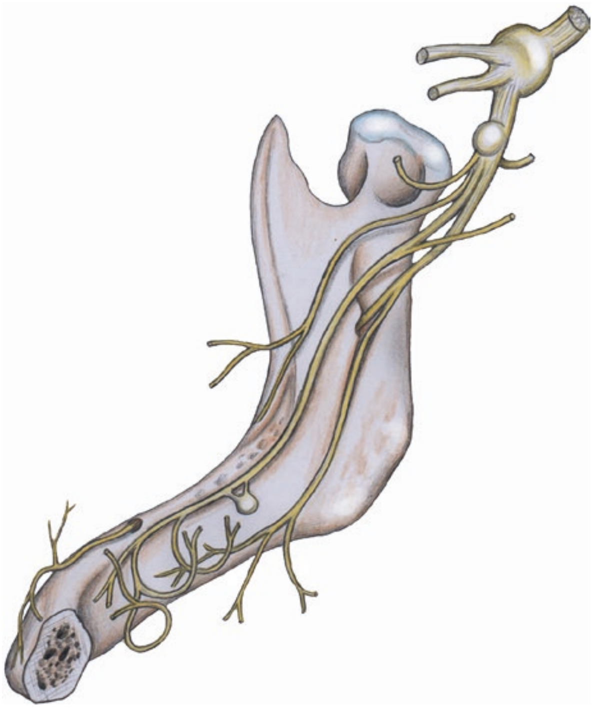


Fig. 1.37 Atrophic mandible: dense D1 bone in the mental area. The mandibular nerve foramen opens out on the crest. Lingual and mandibular nerves are critical structures that must be protected during surgery

Fig. 1.38 Missing central incisor with complete loss of the buccal plate replaced by a double Diskimplant®

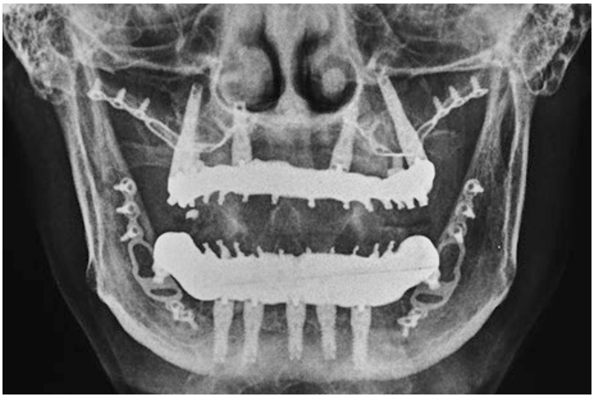


Fig. 1.39 Front view of a basal rehabilitation of an atrophic maxilla and mandible using an immediate loading protocol. Root-form implants were combined with plate-form Diskimplants®. The basal implants were screwed onto the zygomatic process and the trigone area using 5 mm long orthopedic screws. Radiographic status after 2 years of service (2015–2017)

Atrophic Maxilla

The limits of maxillary sinus buccal landmarks are easily identified because basal implantology is a full-flap procedure. Atraumatic elevation of the periosteum by gently separating the tissues using a gauze pad avoids injury to the inner layer of the periosteum and inadvertent penetration of the sinus through the fragile eggshell-thin lateral wall. The bottom and the vertical borders of the nasal fossae must be delineated during flap elevation. The entire bony structure must be visualized before starting osteotomy. Where applicable, the infraorbital foramen must be exposed; the infraorbital nerve remains in the full-thickness buccal flap.

Sharp crestal soft tissue incisions should be made until the scalpel reaches the bone crest. During osteotomy, the soft tissues and nerves should be protected by holding them with a large, rigid plastic suction tube maintained firmly against the buccal bony plate. In the tubero-pterygoid area, full-thickness buccal and palatal mucoperiosteal flaps are elevated using the same approach. Major and minor palatal arteries must remain in the full-thickness palatal flap. This can be obtained by remaining in close contact with the palatal bone during flap elevation. Use the gauze separation technique and a flap retractor.

Atrophic Mandible

Two critical anatomic elements must be avoided during basal implant installation: the lingual nerve and the mandibular nerve. A sharp crestal incision should always be made in the middle of the remaining attached gingiva. The scalpel must be in contact with the bony crest.

The full-thickness flap must be elevated from the lingual side first, always keeping close contact with the bony wall. The gauze separation technique is recommended to avoid damaging the periosteum or mandibular nerve. This technique also eliminates the risk of injuring the lingual nerve because this structure remains inside the lingual flap. This is important because the lingual nerve cannot be visualized on CT scans or cone beam CT exams. The procedure is then repeated from the buccal aspect in order to identify the mental foramen. As for the atrophic maxilla, critical soft tissue structures can be easily protected during rotary osteotomy by holding a large plastic suction tube firmly against the bony plate.

Recommended Reading

1. Misch CE. Density of bone: effect on treatment plans, surgical approach, healing and progressive bone loading. Int J Oral Implant. 1990;6:23–31.
2. Wolff J. Das Gesetz der Transformation der Knochen. Berlin: A Hirschwald; 1892. (English translation published in 1986 by Springer-Verlag).
3. Jaffin RA, Berman CL. The excessive loss of Brånemark fixtures in type IV bone: a 5-year analysis. J Periodontol. 1991;62:2–4.