Brånemark’s discovery of osseointegration arguably became one of the most significant events in dentistry in the twentieth century [1,2]. It could be stated that this discovery divided dentistry into two periods: pre-implant era or era of symptomatic (symptom-driven) dentistry and an implant era or era of physiologic dentistry. In the first period, restorative dentistry had only two meaningful treatment options for failed teeth or edentulous jaws: removable dentures and fixed bridges. Both removable dentures and fixed bridges relied on support of adjacent teeth and underlying alveolar mucosa with little consideration for bone preservation.

For the last 50 years of the second and modern period of dentistry, restorative (reconstructive) dentistry has been utilizing physiologic treatment by replacing missing or failing teeth with bone-anchored (osseointegrated) endosseous implants that have an ability to maintain the alveolar bone in a similar manner to a natural dentition. A new principle of bone preservation was based on the concept of endosseous bone loading (EBL). Dental implants also removed an unnecessary load from adjacent teeth, thus decreasing and eliminating deteriorating effects of removable and fixed tooth-borne prostheses on natural dentition, strengthening masticatory function, and improving esthetics and patient’s comfort.

Initially surgically driven, implant dentistry was concerned mainly with an implant integration of dental implants. It was soon to become clear that in order to properly restore endosseously placed implants, they have to be inserted into the bone in a restoratively driven position, identical or close to where the natural teeth used to be, even if bone was no longer available in the area. Implant dentistry has emerged as a prosthetically driven surgical–restorative discipline.

In the last few decades, it became clear that success of implant dentistry and longevity of dental implants depend on three factors (“implant triangle”). These factors are: (1) a proper restoratively driven placement of implants, (2) the presence of a sufficient amount of bone stock, a foundation for the osseointegration, and (3) the presence of healthy peri-implant soft tissue for proper implant hygiene and maintenance. Missing any one component of the implant triangle tends to eventually result in compromise of implant health or longevity, and can often lead to implant failure.

The presence of bone atrophy or resorption due to tooth loss and trauma (among many other factors) has led to the development of a variety of implant-driven bone augmentation procedures in a single or staged fashion. This two-volume book is about bone augmentation techniques applicable to implant dentistry. A variety of bone augmentation procedures for the deficient (atrophied) alveolar bone has been proposed in the literature [3–5] and are described in these two books. Each method has its indications and contraindications, its proponents and opponents. The following four alveolar ridge reconstruction techniques are frequently used in oral implantology and are described in this book:

1. Guided bone regeneration (GBR) with particulate bone graft [6,7].
3. Ridge-split/bone graft and sandwich osteotomy [12–14].
4. Alveolar distraction osteogenesis [15,16].

To simplify learning of the surgical techniques, the editor (Tolstunov) of this book divided them roughly into two categories: horizontal augmentation and vertical (volumetric) augmentation. Book I inspects horizontal bone augmentation of alveolar ridges with bone width deficiency and Book II scrutinizes vertical bone augmentation of alveolar ridges with bone height loss. Both books do not claim to be a complete all-inclusive dissertation of all alveolar bone augmentation techniques. That would be impossible and impractical. Many surgical techniques are being proposed almost daily on the pages of peer-review oral surgical, periodontal, implant, and general dental journals and other publications. They are also often modified from the original versions with the discovery of new instrumentation and computer technology.

Classifications tend to simplify learning of a certain subject. They often give a reader a “bird’s-eye view” of the complex topic. There is a variety of different classifications of alveolar bone augmentation in implant dentistry. Table 1.1 demonstrates the editor’s classification. Based on years of teaching, practicing and in the process of writing this book, we offer the classification that can, hopefully, be well understood by students, surgical residents, and doctors, and be conceptually robust from the biologic point of view. Examine Table 1.1 after finishing this chapter.

The editor’s recommendation for readers of this two-volume book is to open the book on any chapter that seems clinically relevant at that particular moment and read/learn/study the technique thoroughly. Targeted (selective) reading is common and productive in medical literature. After finishing one chapter, you might want to come back later to the same chapter to re-think its content. Then, move on to another chapter on a different type of
(horizontal or vertical) augmentation for comparison, as well as read current literature on this subject. This might help you to eventually select the technique that suits you (feels best in your hands). Always remember the biologic rationale of each procedure when selecting the one to help your particular patient.

For a novice dental surgeon or an experienced dental practitioner while studying surgical methods and techniques, I would suggest paying special attention to the following:

1. Soft tissue versus hard tissue augmentation: what is needed and what is the priority, especially in the esthetic zone.

2. Static versus dynamic bone augmentation techniques: block graft versus distraction osteogenesis, ridge-split versus orthodontic forced eruption, etc.

3. Two-dimensional (2D), three-dimensional (3D), and, finally, “four-dimensional” (4D) tissue augmentation: horizontal or vertical (2D) versus volumetric (3D) versus time-dependent bone and soft tissue grafting (considering the fourth dimension), with emphasis on aging changes that can be predicted and prevented by thoughtful augmentation techniques (especially, in the anterior maxilla).

<table>
<thead>
<tr>
<th>Types</th>
<th>Graft donor site</th>
<th>Type of augmentation</th>
<th>Graft type, flap type, and graft revascularization</th>
<th>Graft consolidation</th>
<th>Augmenting tissues</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Inlay (interpositional) bone graft: A. Particulate 1. GBR (three–four-wall tooth socket or bone defect)</td>
<td>None or autogenous (if used)</td>
<td>Static</td>
<td>Free graft</td>
<td>Limited mucoperiosteal flap; endosteal (mainly) revascularization</td>
<td>Woven-to-lamellar; starts with bone formation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hard tissue</td>
</tr>
<tr>
<td>II. Onlay (juxtaposed) bone graft: A. Particulate 1. GBR (one–two-wall socket or bone defect) or subperiosteal tunnel</td>
<td>None or autogenous (local or distant)</td>
<td>Static</td>
<td>Free graft, mucoperiosteal flap; endosteal (mainly) revascularization initially, additional vitality from reattached periosteum comes in 3-4 weeks.</td>
<td>Woven-to-lamellar; starts with bone formation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local (intraoral) or distant (extraoral)</td>
<td></td>
<td></td>
<td></td>
<td>Hard tissue</td>
</tr>
<tr>
<td>III. Alveolar distraction osteogenesis</td>
<td>None</td>
<td>Dynamic</td>
<td>No graft, mucoperiosteal flap Endosteal (mainly) and periosteal revascularization (lingual or palatal)</td>
<td>Callus formation, similar to fracture healing, intramembranous (mostly) ossification followed by bone remodeling</td>
<td>Hard and soft tissue (simultaneously distracted/expanded)</td>
</tr>
<tr>
<td>IV. Free bone flap transfer (with microvascular anastomosis)</td>
<td>Distant</td>
<td>Static</td>
<td>Free bone–soft tissue flap Microanastomosis between local (recipient) and distant (donor) vascular networks plus endosteal (recipient) revascularization</td>
<td>Callus formation, similar to fracture healing, endochondral ossification followed by bone remodeling</td>
<td>Hard and soft tissue (simultaneously transferred)</td>
</tr>
</tbody>
</table>
Use this book as a surgical reference guide or manual at any locations – at the university, home, or in the operative room – and let us know what you liked or did not like, and what you would change, add, or delete in future editions of this book. We want each new edition to be better that the one before. Good luck on your learning journey for the benefit of your patients.

I. Particulate bone grafting
1. For INLAY grafts consider xenograft, possibly with autogenous bone (including bone morphogenetic protein (BMP)). Ideally, implant neck and apex are to be positioned in the native bone while the implant body is to be surrounded by the grafted bone. Primary implant stability in the native bone is important.

2. For ONLAY grafts consider mixed xenograft, possibly with autogenous bone (including BMP). Implant neck is to be surrounded by the grafted bone, while the implant body is to be placed into the native bone with good primary stability (30 + N Cm) at the time of insertion.

Tenting procedures for the particulate graft
1. Cortical autogenous tenting. Detached free cortical bone block in width or height-deficient ridges is used for a 2D augmentation with a particulate graft positioned in between the cortical block and basal (native) bone as an INLAY graft. Separated cortical “tenting” free bone has no blood supply initially and 4-5 weeks later—some re-established periosteal source of revascularization only, which limits its survival and increases its impending resorption. Both endosteal and periosteal revascularization are provided for the particulate graft that has a good survival potential.

2. Ti-mesh tenting. Titanium mesh is used for 3D (volumetric) reconstruction of the collapsed ridge and functions as a scaffold protective device for the particulate graft underneath. The particulate graft is placed in ONLAY fashion on top of native bone. Endosteal revascularization is provided for the particulate graft that has a good survival potential.

3. Periosteal tenting
(a) Screw tenting: a soft tissue matrix is tented by metal screws for space creation for the particulate graft placed in ONLAY fashion on top of native bone. Both 2D and 3D ridge augmentations are possible (horizontally and vertically positioned screws). Endosteal and periosteal revascularizations are provided for the particulate graft that has a good survival potential.

(b) Implant tenting: a soft tissue envelope is tented by dental implants for space creation for the particulate graft placed in ONLAY fashion on top of native bone. A 2D ridge augmentation in height-deficient ridges is possible. Endosteal and periosteal revascularization are provided for the particulate graft that has a good survival potential.

II. Block bone grafting
Onlay or inlay, horizontal, vertical or combination (J-graft), fixation screws and plates. Secondary bone resorption often occurs.

III. Alveolar distraction osteogenesis
Horizontal or vertical, specific distractor devices.

IV. Free distant bone flap transfer with microvascular Anastomosis
Vertical and horizontal, plates and screws.

Graft Revascularization implies bone healing (from angiogenesis to mineralization and ossification) from the particular vascular source:
1. Endosteal (central or centrifugal). Bone-to-bone healing (ossification) through angiogenesis. This applies to any onlay or inlay grafts and also for a gap osteotomy created by osteoperiosteal flaps (as in the ridge-split procedure). This is a dominant source of blood supply needed for free bone graft survival.
   (a) Particulate graft: internal “coagulum” is converted into the woven bone; fast revascularization through bone formation.
   (b) Block graft: plasmatic imbibition to block graft; slow revascularization through resorption.

2. Periosteal (peripheral or centripetal). Periosteal proximal angiogenesis to the grafted bone that is exposed to the juxtaposed periosteum (as in an onlay block graft). This is a supplementary source of blood supply needed for free bone graft survival.

3. Microvascular anastomosis. The best source of blood supply. Vascular free graft with hard and soft tissue transfer. The endosteal and periosteal sources are also established and are supplementary.

References
Introduction


