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# Preprosthetic and maxillofacial surgery

Biomaterials, bone grafting  
and tissue engineering

Edited by Joël Ferri and Ernst B. Hunziker

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Joël Ferri and Ernst B. Hunziker



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Published by Woodhead Publishing Limited,  
80 High Street, Sawston, Cambridge CB22 3HJ, UK  
www.woodheadpublishing.com

Woodhead Publishing, 1518 Walnut Street, Suite 1100, Philadelphia,  
PA 19102-3406, USA

Woodhead Publishing India Private Limited, G-2, Vardaan House,  
7/28 Ansari Road, Daryaganj, New Delhi – 110002, India  
www.woodheadpublishingindia.com

First published 2011, Woodhead Publishing Limited  
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British Library Cataloguing in Publication Data  
A catalogue record for this book is available from the British Library.

ISBN 978-1-84569-589-7 (print)  
ISBN 978-0-85709-242-7 (online)

The publisher's policy is to use permanent paper from mills that operate a sustainable forestry policy, and which has been manufactured from pulp which is processed using acid-free and elemental chlorine-free practices. Furthermore, the publisher ensures that the text paper and cover board used have met acceptable environmental accreditation standards.

Typeset by RefineCatch Limited, Bungay, Suffolk, UK  
Printed by TJI Digital, Padstow, Cornwall, UK

# Contents

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	<i>Contributor contact details</i>	<i>xi</i>
	<i>Introduction</i>	<i>xvii</i>
1	Bone tissue engineering	1
	U. MEYER, Düsseldorf University Hospital, Germany, H. P. WIESMANN, J. NEUNZEHN and U. JOOS, Münster University Hospital, Germany	
1.1	Introduction	1
1.2	Bone-repair strategies	2
1.3	Biophysical effects	4
1.4	Distraction osteogenesis	5
1.5	Biomolecules	6
1.6	Transplantation of cells	7
1.7	Flap prefabrication	8
1.8	Extracorporeal strategies	9
1.9	Cell systems	9
1.10	Evaluation of engineering success	14
1.11	References	15
<b>Part I</b>	<b>Bone reconstruction in implantology and reconstructive preprosthetic surgery</b>	<b>23</b>
2	Fundamentals of bone grafting in implantology	25
	P. J. W. STOELINGA, Radboud University Medical Centre, Nijmegen, The Netherlands, J. I. CAWOOD, Consultant Oral and Maxillofacial Surgeon, Chester, UK	
2.1	Introduction	25
2.2	Scheme for pre-implant surgery	25
2.3	Fundamentals of bone grafting	28
2.4	Local bone grafts	31
2.5	Distant bone grafts	32

vi	Contents	
2.6	Conclusions	34
2.7	References	34
3	Cranial bone grafting in maxillary preprosthetic surgery J. F. TULASNE, Zedental.com, France	36
3.1	Introduction	36
3.2	Experimental studies	36
3.3	The surgery	37
3.4	Discussion	45
3.5	Conclusions	48
3.6	References	52
4	Maxillary sinus grafting for implant insertion J. ACERO, Complutense University of Madrid, Spain	54
4.1	Introduction	54
4.2	Anatomic fundamentals: pathophysiology	56
4.3	Treatment planning: indications and contraindications	58
4.4	Types of maxillary sinus augmentation for implant insertion: surgical technique	60
4.5	Grafting materials	63
4.6	Results	71
4.7	Complications of sinus lift	71
4.8	References	73
5	Symphyseal and alveolar reconstruction in preprosthetic surgery D. GOGA, F. SURY and T. TAYEB, Trousseau University Hospital, France	76
5.1	Introduction	76
5.2	The height improvement	76
5.3	The increase of thickness	83
5.4	Particular aspects	96
5.5	Failure risk factors and complications	97
5.6	Implant placement at the mandibular symphysis	99
5.7	Indications and limits of the implant placement at the symphysis region	100
5.8	Conclusions	102
5.9	References	102
6	Mandible corpus reconstruction for implant insertion: the available techniques J. FERRI and L. LAUWERS, Roger Salengro University Hospital, France	104
6.1	Introduction	104
6.2	Anatomical considerations	105

6.3	Different techniques	105
6.4	Case studies	109
6.5	Conclusion and indications	109
6.6	References	113
7	Alveolar bi-directional distraction in preprosthetic surgery T. IIZUKA, Bern University Hospital, Switzerland	115
7.1	Introduction	115
7.2	Indications for distraction	115
7.3	Why is a bi-directional distraction necessary?	116
7.4	Bi-directional distraction device	119
7.5	Surgical technique for bi-directional distraction	121
7.6	Insertion of dental implants and suprastructure	123
7.7	Histology and histomorphometry of distracted bone	124
7.8	Complications and need for technical improvements	127
7.9	Conclusions	128
7.10	References	128
8	Alveolar widening using distraction osteogenesis (DO) in maxillofacial surgery T. TAKAHASHI and K. YAMAUCHI, Kyushu Dental College, Japan and T. IIZUKA, Bern University Hospital, Switzerland	130
8.1	Introduction	130
8.2	Alveolar distraction osteogenesis (DO)	131
8.3	Horizontal alveolar distraction	132
8.4	Horizontal periosteal expansion osteogenesis	151
8.5	Histological evaluation	155
8.6	Conclusions	155
8.7	References	156
9	Bone grafting and Le fort I osteotomy in cases of major atrophy of the maxilla J. FERRI and L. LAUWERS, Roger Salengro University Hospital, France, P. ELIA and H. DUBOIS, Private practice, France	158
9.1	Introduction	158
9.2	Anatomical consideration of the maxilla	158
9.3	The different steps of the technique	161
9.4	Discussion	166
9.5	Case study	168
9.6	Conclusions	171
9.7	References	172



<b>Part II</b>	<b>Reconstruction in particular situations</b>	<b>173</b>
10	Applications of biomaterials in alveolar and maxillofacial bone reconstruction U. JOOS, H. P. WIESMANN and J. NEUNZEHN, Münster University Hospital, Germany, U. MEYER, Düsseldorf University Hospital, Germany	175
10.1	Introduction	175
10.2	Substitute materials	176
10.3	Synthetic inorganic materials	176
10.4	Synthetic organic materials	177
10.5	Natural inorganic materials	178
10.6	Natural organic materials	179
10.7	References	180
11	Implants in congenital missing teeth L. LAUWERS, T. WOJCIK, G. RAOUL and J FERRI, Roger Salengro University Hospital, France	185
11.1	Introduction	185
11.2	Diagnosis	186
11.3	Management	186
11.4	Rehabilitation cases	191
11.5	Conclusions	197
11.6	References	198
12	Maxillo-mandibular amputations and implants rehabilitation J. FERRI, G. RAOUL and L. LAUWERS, Roger Salengro University Hospital, France, B. DESMET, Private practice, France, P. BRETON, Central Hospital South Lyon, France	199
12.1	Introduction	199
12.2	Strategy for jaw reconstruction	200
12.3	Basal bone reconstruction	203
12.4	Preparing endosseous implant-step	214
12.5	Illustrations of implant-borne prosthesis after jawbone reconstruction	222
12.6	Conclusions	231
12.7	References	232
13	Alveolar reconstruction in cleft for implant rehabilitation J-B. SEIGNEURIC, Military Instruction Hospital BEGIN, France and M-P. VAZQUEZ, Pierre and Marie Curie University, France	236
13.1	Introduction	236
13.2	Management of orofacial clefts	237

13.3	Implant placement in cleft lip and palate (CLP)	243
13.4	Success rates of implant placement	258
13.5	Conclusions	258
13.6	References	259
14	Bone reconstruction in irradiated situations N. FROGET, A. PIERREFEU, M. KOPPE and P. BRETON, Centre Hospital, South Lyon, France	264
14.1	Introduction	264
14.2	Adjuvant treatment	265
14.3	Non-vascularised bone graft	266
14.4	Coverage flaps	266
14.5	Free flap and bone graft association	271
14.6	Vascularised bone transfers	271
14.7	New techniques	277
14.8	Reconstruction principles in irradiated situations	280
14.9	References	281
15	Periodontal surgery related to alveolar bone reconstruction for implant insertion M. LECONTE, T. WOJCIK, J. FERRI, Roger Salengro University Hospital, France, M. MONGEOT, Private practice, Lille, France	284
15.1	Introduction	284
15.2	Muco gingival environment around natural teeth	284
15.3	Role of the keratinized gingiva around the implants	285
15.4	Developing a favourable environment around the implants	285
15.5	Surgical technique	290
15.6	Conclusions	300
15.7	References	301
<b>Part III</b>	<b>Tissue engineering</b>	<b>303</b>
16	Mucosal and gingival tissue engineering R. NEIVA and W.V. GIANNOBILE, University of Michigan School of Dentistry, USA	305
16.1	Overview of oral soft tissue wound healing	305
16.2	Traditional approaches	307
16.3	Novel approaches for oral soft tissue repair	309
16.4	Future trends	319
16.5	Acknowledgments	319
16.6	References	319

x	Contents	
17	Osteoinductivization of dental implants and bone-defect-filling materials	327
	E. HUNZIKER, University of Bern, Switzerland	
17.1	Introduction	327
17.2	Biomimetic coating technique	327
17.3	Conclusions	333
17.4	References	333
18	Tissue engineering and endodontics	336
	S. SIMON, Cordeliers Research Centre, France and University of Birmingham, UK, P. COOPER, University of Birmingham, UK, J. ISAAC and A. BERDAL, Cordeliers Research Centre, France	
18.1	Introduction	336
18.2	The dentine-pulp complex	338
18.3	Pulpal responses to injury	345
18.4	Pulp capping and dentine-pulp complex regeneration	351
18.5	Root canal tissue regeneration	353
18.6	Conclusions	357
18.7	References	357
19	Tooth regeneration: current status	363
	J. J. MAO, Columbia University Medical Center, USA	
19.1	Introduction	363
19.2	Translational barriers of tooth regeneration and dental pulp regeneration	364
19.3	Cell homing approach for tooth regeneration	366
19.4	Discussion and future trends	369
19.5	Acknowledgments	370
19.6	References	370
	<i>Index</i>	375

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Ever since osteointegration principles were established by Bränemark, the use of implants in oral and maxillo-facial surgery are being more widely developed throughout the world. Use of these techniques has never been abandoned. The innumerable publications on the theme of oral implantology show the interest of the medical community for these rehabilitations.

However, even though implantations are exceptionally successful a minimum of bone is mandatory to guarantee a primary stability and so assure the bone integration. Whenever this bone is not present the implant insertion is more complicated requiring complex or more uncertain techniques. For these cases pre-prosthetic implantation surgery has been developed in order to repair the missing or insufficient bone in order to admit a simple implant insertion.

Classically, the reconstruction is done using the autogenous cancellous bone. Progressively, after development by many surgeons, the use of membranous bone has been suggested in order to assure both a less painful harvesting and a lower resorption rate. However, in complex cases such as amputations or after irradiation, the use of vascularized bone flaps or distraction procedures are the only solutions possible. Today these techniques are used widely throughout the world and permit the reconstruction of just about any deficit in nearly any situation.

Despite all this, and even for very simple surgery, any bone harvesting has a certain morbidity forever present in the surgical procedure. To lessen this morbidity the surgeons have ‘dreamed’ of being able to repair bone by ‘creating’ it from structures which would not be harvested from the patient. In this optic the use of biomaterials has been developed. These techniques have vastly progressed using scaffold, stem cells (to induce bone and blood vessels) and proteins which stimulate the bone growth. However despite the quality of the re-construction techniques using these biomaterials none have replaced the autogenous bone graft, which remains the ‘gold standard’ of bone reconstruction.

Far beyond bone reconstruction today's biotechnologies are studying how to make absent or lost teeth grow again. This is a major challenge for which we can imagine the consequences in maxillary reconstruction. In the light of their progress this dream could soon become reality. . .

The objective of this work is to take stock of all these techniques permitting the reconstruction of the bone which supports the implants and also to consider the future and bring to light all the possibilities that biomaterials and tissue engineering can offer. To this aim this work has been divided in three parts.

The first part (bone reconstruction in implantology and reconstructive pre-prosthetic surgery) talks of the techniques, which although recent, have been validated by the international medical community. It enlightens the reader on today's possibilities of reconstruction with recognized procedures even though the choice of techniques is often a subject of discussion.

The second part (reconstruction in particular situations) studies the reconstruction in certain circumstances. It guides the reader on particular cases. The techniques used are often complex for situations which are often complex themselves. For instance implants rehabilitation in irradiated fields or in cleft lip and palate are studied in this section.

The third part covers tissue engineering. It carries out a study on the state of what is known today about bone, gums and dental organs creation. It is an open window on the techniques which could rapidly become revolutionary in dento-maxillo-facial reconstruction.

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**Abstract:** In modern regenerative medicine and tissue engineering, the reconstruction and repair of bony defects is one of the most intensively investigated subjects. Standard surgical approaches that are currently implemented to facilitate the repair of osseous tissue include guided bone regeneration, distraction osteogenesis and the autotransplantation of bone. In the field of tissue engineering, extracorporeal strategies, such as flap prefabrication and the seeding of biocompatible scaffolds with either stem cells, committed osteoprogenitor cells or osteoblast-like cells, are favoured options. In this chapter, the limitations and potentials of the various techniques and strategies are addressed.

**Key words:** bone-tissue engineering, bone repair, autologous bone, guided bone regeneration, distraction osteogenesis.

## 1.1 Introduction

Bone repair is one of the most intensively investigated subjects in reconstructive surgery (for a review of this topic, see Schultz *et al.*, 2000). Current approaches to skeletal reconstructive surgery make use of biomaterials, autografts or allografts, but each technique has its drawbacks. These include donor-site morbidity and shortage of material for autografts (Damien and Parsons, 1991), immunological problems and the risk of transmitting infectious diseases for allografts. Many artificial materials, such as metals, ceramics and polymers, have been used as substitutes for bone in maintaining skeletal function (Binderman and Fin, 1990), none of which is an ideal replacement for autologous osseous tissue in current clinical practice. The use of biomaterials is a common treatment option. One of the main advantages of tissue grafts over non-living biomaterials is that they contain living cells and tissue-inducing substances which confer biological plasticity. Research is currently in progress to develop cell-containing hybrid materials and to create replacement tissues that remain interactive after implantation, imparting physiological functions as well as structure to the tissue or organ damaged by disease or trauma (Alsberg *et al.*, 2001).

In the field of tissue engineering generally, and not least in that relating to bone, living cells are exploited in various ways to restore, maintain or enhance tissue functions (Langer and Vacanti, 1993; Lysaght and Reyes, 2001). There exist three principal therapeutic strategies for treating diseased or lost tissue in patients: (i) *in-situ* tissue regeneration, (ii) implantation of freshly isolated or cultured cells,