Minimally Invasive (MI) Orthognathic Surgery

Gwen R.J. Swennen
Editor

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A Systematic Step-by-Step Approach

Springer

Editor
Gwen R.J. Swennen
Department of Surgery
Division of Maxillofacial Surgery and Facial Plastic
Surgery, AZ Sint-Jan Brugge-Oostende AV, Belgium
Bruges, Belgium

ISBN 978-3-031-38011-2 ISBN 978-3-031-38012-9 (eBook)
https://doi.org/10.1007/978-3-031-38012-9

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

I want to dedicate this book to my family and to my fellows Yves and Fernando who made this "impossible" project "possible" …
Gwen R.J. Swennen

Foreword

A lot of books have been written about orthognathic surgery, but I think none as well illustrated and timely.

The aim of this book is to introduce the concept of minimally invasive (MI) surgery for the standard orthognathic surgery procedures. Doing this safely, precisely, and efficiently involves a lot of prescriptions, starting with the planning but also during the perioperative phase and aftercare. This book describes in great detail all aspects that are essential for that facilitate MI orthognathic surgery.

There is a lot of evidence in most surgical disciplines that MI surgery has brought about a lot of advantages: better outcomes, faster recovery for the patient, less comorbidities, shorter hospital stays, and better cost-efficiency. The laparoscopy has pushed the laparotomy into a very small corner with few indications. Endoscopic procedures have also been tried in Oral and Maxillofacial (OMF) Surgery in general as well as orthognathic surgery. But for now, at least there is no evidence that an endoscopic approach for the basic orthognathic techniques is viable. Until maybe the day that robotics, navigation, and artificial intelligence (AI) make a quantum leap of progress for these specific indications. Mind you, there are first anecdotal reports on robotic insertion of dental implants. So, the alternative to endoscopic orthognathic surgery consists then in minimizing the length of the incision, extend the tunnelling of the flaps and limiting the areas of degloving of the periosteum. And to do so in an optimal systematic way for all basic orthognathic procedures. Other criteria of course are protection of the tissues thus avoiding damage, creating adequate access and visibility of the target areas, and achieving the simulated results and length of the surgical procedure.

More importantly, there is sound biological thinking behind the concept of MI orthognathic surgery. The rationale is very well explained and underpins the rationale for the following chapters. Making incisions shorter and safe degloving can be done by moving the incision further away from the mucogingival border. This will lead to less risk of gingival retractions and periodontal damage. Obviously, a short incision along the inside of the upper lip combined with atraumatic tunnelling toward the maxillary tuberosity leads to equally good exposure as a long incision just above the mucogingival border extending from one molar to the contralateral one. But the former will keep the non-randomized blood supply of the buccal flap intact and the degloved area can be limited vertically to the osteotomy level, without disturbing the periosteal attachment and blood supply to the alveolar process. Avoiding acute ischemia at the time of osteotomy and down-fracture as well as long-term chronically decreased intra-osseous oxygen tension are essential to avoid damage to teeth and periodontium. Some reports suggest significantly increased occurrence of dental pulp obliteration following “classical” approaches for Le Fort I osteotomies. And we do not want to create an ideal smile line, with exposure of the interdental papillae, while at the same time risking losing the fullness of these by chronic low-grade ischemia that could result in black interdental triangles. It is therefore important to keep this buccal flap as broad as possible and as well attached to the inferior portion of the maxilla as possible. This source of blood supply becomes even more critical in case of surgical damage to the major palatine artery and in some cleft cases where this blood supply is compromised.

Similarly, minimal but safe degloving is advantageous for the sagittal split osteotomy (SSO). Maintaining blood supply to the condylar head and neck is important for the long-term stability of the condylar volume, which seems to be affected by these osteotomies. And there is no need for aggressive stripping of the masseteric mandibular insertion along the entire length of the mandibular angle, as this can lead to excessive and unpredictable resorption of the gonial angle, having devastating aesthetic consequences in some cases.

Executing a surgically assisted maxillary expansion via a small endonasal incision and approach on both sides of the piriform rim illustrates best the principle of "minimally invasiveness," combined with long tunnelling and safe handling of the cutting instruments. This approach indeed creates "closed boxes" where the distraction osteogenesis (DO) can occur undisturbed. Obviously, under the correct circumstances this approach will also lead to minimal bleeding, swelling, and discomfort for the patient with optimal postoperative fast recovery.

Equally the MI orthognathic approach for the genioplasty results in minimal incision, safe and minimal degloving, and adequate fixation of the well-vascularized chin prominence.

The author has convincingly demonstrated in this book that criteria of safety, efficiency, maximizing blood supply, and minimizing morbidity can be met. This requires a number of preconditions that all should be fulfilled. The first one was the development of new adapted instruments that allow for easy manipulation of the target areas via small incisions and long narrow tunnels. Instead of this being a risky leap of faith with unknown risk when trying this out, which we should not do, the author describes a standardized routine to proceed safely, swiftly, and precisely in a non-traumatic way.

The core of the book consists of step-by-step description and illustration of the basic orthognathic procedures in a "Minimally Invasive (MI) Approach" with a "Minimally Invasive Mindset": Le Fort I osteotomy, bilateral sagittal split osteotomy, genioplasty, surgically assisted maxillary expansion. Those illustrations have a consistent format consisting of graphically representing the correct use of surgical instruments using cadaveric specimen, synthetic skulls, clinical drawings, and highlighted text blocks. The quality of the photography and illustrations is superb, not to mention perfect. These illustrations accompany the step-by-step description of all relevant surgical actions during a specific procedure. These descriptions are detailed and self-explanatory. These chapters and their illustrations must have been a huge and time-consuming effort for all involved, not at least the photographer and the illustrator.

Obviously, using new instruments alone will not lead to better or less invasive surgery.

Professor Swennen has to be commended for describing in detail all other aspects that are key for a successful outcome. These deal with the preparation of the patient immediately prior to surgery, the anesthetic protocols, hypotension, local vasoconstriction, the positioning of the assistants and the nurse, the use of a specific extension of the OR-table, and all aspects of the aftercare.

But actually, the MI orthognathic procedure starts much earlier. If we are going to make small incisions combined with long tunnels and minimal degloving, we must know exactly where the osteotomy cuts will be and where there will be interferences that need removing, so that we can stick to the MIS principles. That is where precise planning is essential. The authors describe in detail the clinical examination and documentation that are essential for the surgical planning as well as the 3D planning itself which should be done by the surgeon him/herself, so that they have detailed insight not only of the surgical movements they are planning but also all details relevant for MIS.

As we all know, a good research paper should be written such that an experiment can be duplicated elsewhere in an identical way, leading to identical or similar results. It seems to me that this book allows exactly to achieve this as well. The solid structure of the book, the amount of details, and the illustrations should allow for that once the team is beyond the learning curve. As for the learning curve itself, this can be shortened significantly by following the step-by-step instructions and illustrations in a simulated situation as illustrated in the book.

I wish to congratulate Professor Gwen Swennen, the photographer Valerie Swennen-Boehlen, and all contributors with this detailed atlas of excellent quality.

Professor Gwen Swennen cites in his book Theodore Lewitt: “Creativity is thinking up new things, innovation is doing new things.” I think that he has proven what innovation is. With a relentless passion and hard work over the past decades, he has developed an innovative way to perform minimally invasive (MI) orthognathic surgery based on precise 3D virtual planning and simulation, as well as creating modified instruments to facilitate MIS. All of what is explained in this atlas, is backed by multiple peer-reviewed papers. His two previous books were innovating the area of 3D cephalometry (2005) and 3D virtual planning (2016). This new book eloquently squares the circle of innovation in orthognathic surgery.

Piet Haers
Oral and Maxillofacial Surgery,
Guildford Nuffield Hospital
Guildford, UK

Dental Implant and Maxillofacial Centre
Hong Kong

Foreword

Orthognathic surgery has witnessed a phenomenal paradigm change in the last two decades. This change has been driven by two specific factors, namely: 3D planning and improvement of surgical techniques. The advancement of 3D planning has allowed surgeons to design skeletal surgery in a predictable and accurate manner, yielding a significant improvement in surgical outcomes. Gwen Swennen, undoubtedly one of the top oral and maxillofacial surgeons in the world, has definitely contributed to this development and in cooperation with KLS Martin designed a comprehensive user-friendly platform for 3D planning.

Minimally invasive surgical techniques have revolutionized the field in recent years. In this new book, Gwen and his coauthors provide a comprehensive overview of different orthognathic surgical techniques in an orderly and well-structured manner. Drawing on his years of experience, Dr. Swennen offers an in-depth and practical analysis of the latest techniques, used in orthognathic surgery. I am happy and honored to see that some of my original published techniques such as our minimally invasive Le Fort I, with a reduced approach using tunnelling techniques, as well as our technique for cross suturing of the nasal muscles to prevent nasal widening, have also been incorporated in the book.

To give a practical twist, the authors again in partnership with KLS Martin have developed an extensive array of surgical instruments for each of the described surgical approaches. Precise indications for each of those instruments are presented in the book.

Overall, this book is an essential resource for anyone interested in orthognathic surgery. It provides a comprehensive overview of the field and is filled with valuable insights and practical advice. Whether you are a novel or experienced surgeon, this book is must-read.

Federico Hernández-Alfaro
Full Professor and chairman, Department of Oral and Maxillofacial Surgery
Universitat Internacional de Catalunya (UIC)
Barcelona, Spain
Director, Institute of Maxillofacial Surgery
Teknon Medical Center
Barcelona, Spain

Preface

There's a way to do it better – find it …
Thomas. A. Edison 1957

Creativity is thinking up new things … *Innovation* is doing new things.
Theodore Levitt 1986

Education is the path to *Innovation* . . .
Peter Serdyukov 2017

For 25 years, I have been focusing on how to decrease patient morbidity and increase postoperative recovery and comfort after orthognathic/orthofacial surgery by continuous self-reflection, research, education, and innovation.

The *Color Atlas and Manual on Three-Dimensional Cephalometry* (Springer, 2005) was an attempt to bridge conventional cephalometry with the 3D virtual approach by the introduction of 3D cephalometry. It is amazing that after more than 18 years the concept of this atlas remains more than actual for both orthodontists and surgeons.

3D Virtual Treatment Planning of Orthognathic Surgery: A Step-by-Step Approach for Orthodontists and Surgeons (Springer, 2017) represented a comprehensive, systematic, standardized but above individualized patient approach toward 3D virtual planning of orthognathic surgery in the daily clinical routine.

Although I promised myself afterwards never to undertake a book project anymore, the intrinsic force toward teaching was just too big. The COVID-19 pandemic with three lockdowns in my country made me aware of how important education is to stimulate research toward innovation for better healthcare.

This new atlas *Minimally Invasive Orthognathic Surgery* represents the third part of a "trilogy" based on a "personal 25 years Odyssey" dedicated to improving overall care of patients with maxillofacial deformity. I sincerely hope that this manual will be a guide for both young and experienced surgeons to increase both their own skills and the quality of life of their orthognathic patients.

Bruges, Belgium
April 2023

Gwen R.J. Swennen

Acknowledgments

First, I need to thank my teachers and mentors Professor Jarg-Erich Hausamen (former chair, Department of OMF Surgery, Hannover Medical University, Hannover), Professor Henning Schliephake (chair, Department of OMF Surgery, Georg-August University, Göttingen), and Professor Chantal Malevez (former chair, Department of OMF Surgery, Queen Fabiola Children´s University Hospital, Brussels) who taught me not only the importance of working hard in order to become an excellent surgeon, clinician, teacher, and researcher but also the values of respect and loyalty. I am also very grateful to Professor Albert De Mey (former chair, Department of Plastic Surgery, University Hospital Brugmann and Queen Fabiola Children's University Hospital, Brussels) and Peter Brachvogel (former staff-member, Department of OMF Surgery, Hannover Medical University, Hannover), both of whom unfortunately passed away too soon, for having trained me in all aspects of facial surgery.

I want to thank all my associate colleagues (Division of Maxillofacial Surgery, Department of Surgery, AZ Sint-Jan Brugge-Oostende AV and AZ St-Lucas, Bruges) for their continuous support and also all residents, international fellows, and course participants whom I was allowed to train over the years. I wish to thank all my referring orthodontists and colleagues for having been working together so nicely the last 18 years in Bruges and look forward to our further collaboration in the future.

I am very grateful to SORG (Strasbourg Osteosynthesis Research Group), Oliver Scheunemann (SORG Secretary General), and his team and all my co-members of the orthognathic section for the excellent and stimulating collaboration over more than 20 years. In particular, I need to thank Professor Peter Kessler (chair, Department of OMF Surgery, Maastricht University, Maastricht) for our successful cadaver courses in Maastricht over more than 10 years and Professor Piet Haers (Oral and Maxillofacial Surgery, Guildford Nuffield Hospital, Guildford, UK; Dental Implant and Maxillofacial Centre, Hong Kong) for always having been pushing and motivating me. I also thank Piet for his nice and honest foreword to this atlas, which means a lot to me. I am also very thankful to Professor Octavio Cintra (SORG Latin America) and Professor Lydia Lim (SORG Oceania) for their help in the first MI Orthognathic cadaver courses in Florianópolis, Brazil and Melbourne, Australia.

An important part of innovation is to be confident about sharing ideas. Especially, I want to thank Professor Federico Hernández-Alfaro not only because through him I had the opportunity to be the co-director of the first Spanish OMF European PhD thesis conducted by Raquel Guijarro Martinez on "Cone-beam computerized tomography evaluation of the upper airway in the context of orthognathic surgery" but also learnt directly through this most special connection, the potential of the pioneering work of Professor Federico Hernández-Alfaro on a minimally invasive approach to the Le Fort I osteotomy, on which the technique described in this atlas is primarily based. Fede, thank you also that you accepted my invitation to write your foreword which is a great honor to me. I also thank Raquel. Of course, I may not forget to thank Professor Mirco Raffaini (Department of OMF Surgery, University of Florence and Founder/Director, Face Surgery Center, Parma, Italy) for having written his foreword to my second book on 3D virtual planning of orthognathic surgery and having been always an inspiration to me.

Toward this third book project, I need to thank so many people who were involved. Nasser AlAsseri (former 1-year fellow Bruges, Riyadh, Saudi Arabia) for his systematic review on minimally invasive orthognathic surgery. Professor Hugo De Clerck (private practice, Brussels, Belgium and adjunct Professor, Department of Orthodontics, University of North Carolina, Chapel Hill, USA) for the synthetic skull with braces and for his initial help already in 2016 in making pictures of the first demo MI orthognathic instruments with the help of Mauricio Demétrio (former 3-month fellow Bruges, São Luis, Brazil). I want to thank Abdulmalik Al-Yahya (former 1-year fellow Bruges, Riyadh, Saudi Arabia), Lies Pottel (Head, Clinical Trial Center, AZ Sint-Jan Brugge-Oostende AV, Bruges), Paulo Bártholo (former 1-year fellow Bruges, Manaus, Brazil), and Matthias Dobbeleire (former resident, Division of Maxillofacial Surgery, Department of Surgery, AZ Sint-Jan Brugge-Oostende AV and AZ St-Lucas, Bruges) for their tireless assistance during the photography sessions on the cadavers. A special thanks to Professor Arno Lataster (former Chair, Department of Anatomy and Embryology, University of Maastricht, the Netherlands) and this team for the possibility and assistance during the surgery on the cadaver specimen in Maastricht. I want to thank Rolando Carrasco (former 1-year fellow Bruges, Santiago, Chili) for his help in the MI orthognathic cadaver courses, and I especially thank Professor Sergio Miranda (Chair, Department of Facial Surgery, São Paulo, Brazil) for his support and personal advice.

True innovation is only possible based on creativity in combination with continuous research, education and last but not least support of the industry to make it happen. I therefore need to thank KLS Martin with more than 150 years of experience in the development of surgical instruments. In particular, I wish to thank Christian Leibinger and Michael Martin for having pushed me to realize this project and for their continuous support. I also need to thank Thomas Samyn, Frank Reinauer, Sebastian Steppacher, Malvin Debono and especially Pascal Dilger, Volker Scheu, and Cederic Mühlmann for their tireless collaboration in the design and production of the MI orthognathic instruments. Moreover, I am very grateful to Tobias Held, Christoph Krüger, Bernard Tsang, Achim Riedle, Hannes Leibinger, Stefan Betzler, Ariane Kiehne, and Moritz Küssner for helping in setting up the educational courses. Of course, special thanks to Monica Hengstler and her team for their invaluable support during the online webinars and phantom web courses and Mayton Chacon and Candido Marques for setting up the cadaver courses.

I want to thank Springer once again for their trust and collaboration in publishing this new project and especially Daniella Heller and Lee Klein for making this wonderful atlas feasible.

Last but not least, I want to thank especially three wonderful persons without whom this project would never have been realized. My two contributors, Yves Weinberg and Fernando Andriola, and my lovely wife Valérie who made all the high-quality pictures shown in this atlas.

Professor Gwen R.J. Swennen MD, DMD, PhD, MSc, FEBOMFS.
Bruges, Belgium, April 2023

First of all, I would like to thank my wife Dorelle and my children Eyal, Aya, and Meshi for their support in this project and their countless sacrifices throughout the years. I am also grateful to my parents, Dr. Avraham Weinberg and Danielle Gourevitch, for being a strong pillar and role model and for their support and guidance. I would like to thank my teachers and mentors, Prof. Oded Nahlieli (Former Chairman, OMF Department, Barzilai Medical Center, Israel), pioneer in minimally invasive surgery and Dr. Amram Zagury (Deputy Chairman), for educating me to be a good clinician. I would also like to thank Prof. Shlomo Calderon (Former Chairman, OMF Department, Rabin Medical Center, Israel), a pioneer and leading orthognathic surgeon in Israel, for giving me the opportunity to learn from him and for his valuable advice. I am grateful to my teachers and colleagues over the years, Dr. Alex Abramson (Chairman, OMF Department, Barzilai Medical Center, Israel), Dr. Guy Weinberg, Dr. Dan Kopeliovich, Dr. Yaron Nazarian, Dr. Liat Hecht-Nakar, Dr. Noam Bruck, Dr. Sagi Sivan, Dr. Yuval Samuni, Dr. Izhar Shohat, Dr. Giovanni Audino, Dr. Rachel Berkun-Horwitz, Dr. Sigal Mazor, and Dr. Roi Keren for their teaching, friendship, and continuous support. A very special thank you also to all the staff members and residents of OMF and Facial Plastic Surgery

Department at AZ Sint Jan hospital, for sharing their wide knowledge during my 1-year fellowship in Bruges, Belgium. Most of all, I want to thank the two people who shared this huge project with me. First to my talented colleague Dr. Fernando de Oliveira Andriola for sharing his clinical and scientific knowledge, for his hard work, for all the wise pieces of advice during the writing process, and for his friendship. Finally, I especially want to thank the editor and lead author of this atlas, Prof. Gwen R.J. Swennen, for being an inspiring teacher and mentor to me, for giving me the opportunity to learn from his tremendous knowledge in 3D treatment planning, from his outstanding surgical skills and innovative minimally invasive techniques, and also for all the amazing tips and advices, for teaching me what standardization and efficiency is, and for giving me the enormous honor of being part of this beautiful project.

Yves Weinberg MD, DMD.
Tel Aviv, Israel, March 2023

Great achievements are only possible if we are surrounded and supported by kind, special, and inspiring people. It has been a gift to have so many of them by my side, both at work and in my personal life. Therefore, I especially want to thank and dedicate this work to my lovely wife Amanda, to my beloved daughter Helena, and to my parents, Débora and Ernani, my greatest supporters and source of inspiration, as well as to all my family, friends, and colleagues. I particularly want to thank my mentor, colleague, and dear friend Prof. Dr. Guilherme Fritscher for all the opportunities entrusted to me during the last 9 years. Many thanks also to Prof. Dr. Angelo Menuci, dear colleague and friend with whom I have the pleasure to work and to continuously learn every day.

I wish to thank my advisor during master's and doctoral period, Prof. Dr. Rogério Pagnoncelli, for his trust and support, and my friend Prof. Dr. Orion Haas who made my Research and Clinical Fellowship in Bruges possible. I am very grateful to all professors, colleagues, and employees of the Pontifical Catholic University of Rio Grande do Sul (PUCRS), which was my second home during residency, masters, and doctorate courses, and where I am very proud to be an Associate Professor today. Thanks to the professors and friends from the Federal University of Rio Grande do Sul, School of Dentistry (FO-UFRGS), my alma-mater, where I graduated in 2013 and had the honor to work as an Assistant Professor in 2019. Special thanks to my dear friend and colleague Prof. Dr. Angelo Freddo, my advisor during the undergraduate course and a great partner during professorship as well. Thanks to the staff members, nurses, secretaries, residents, and fellows of the Division of Maxillofacial Surgery and Facial Plastic Surgery, Department of Surgery, AZ Sint-Jan Bruges-Oostende, Belgium, for their kindness, help, and for everything they taught me during my amazing time in West Flanders. Special thanks to my dear friends Yves Weinberg (Israel), Ugo Amadi (Italy), Thamer Alanezi (Kuwait), Anna Olejnik (Poland) and Giovanni Audino (Italy), with whom I had the pleasure to work during my time in Bruges. Thanks to the Brazilian Government Agency for Higher Education (CAPES) for the opportunity to live and study abroad during my PhD.

Last but *absolutely* not least, what can I say about Prof. Dr. Gwen R.J. Swennen? I just wish more people had the opportunity to work and learn from such an inspiring person like him. It was a priceless opportunity that changed my mind and my perspectives for good. I have no words to express how grateful I am to him for receiving me in the middle of a very tough and uncertain period, during one of the worst parts of the Covid-19 pandemic. He and Valérie were so kind and truly treated me as a family member every time I was in Bruges or Knokke, really making me feel at home. I will never forget how amazing you are!

One of the most remarkable things I learned from him was the slogan of Club Brugge—which I heard him repeating "a few" times and that I will certainly take for life: "No sweat, no glory!" Gwen, thanks for all the opportunities and for everything you taught me, not only in the field of maxillofacial surgery, but also regarding integrity, perfectionism, loyalty, and hard work. It was a great honor to be part of this "impossible" and amazing project. Thank you for your trust and for counting on Yves and me to go for it.

Fernando de Oliveira Andriola DDS, MSc, PhD.
Porto Alegre, Brazil, September 2023

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Contributors

Fernando de O. Andriola, DDS, MSc, PhD Department of Oral and Maxillofacial Surgery, Hospital São Lucas, Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre, Rio Grande do Sul, Brazil

Andriola Odontologia, Porto Alegre, Rio Grande do Sul, Brazil

Yves Weinberg, MD, DMD Oral and Maxillofacial Surgery Division of Surgery, Barzilai University Medical Center, Ashkelon, Israel

1 Background and Introduction to Minimally Invasive (MI) Orthognathic Surgery

Fernando de O. Andriola, Yves Weinberg, and Gwen R.J. Swennen

Minimally invasive (MI) surgery has been described by Hunter in 1999 as a discipline that involves a novel way to perform operative procedures with the main goal of decreasing the sequelae of traditional surgery. In the last two and a half decades, MI surgical approaches were developed in different medical surgical fields and within Oral and Maxillofacial Surgery (OMFS) toward different OMFS procedures such as temporomandibular joint (TMJ), facial trauma and salivary gland surgery. In this chapter, the background of MI orthognathic surgery and development of new MI orthognathic surgical techniques are described. Based on evidence-based literature "MI mindset" parameters and considerations toward optimizing surgical efficiency and decreasing patient morbidity are outlined. Finally, a new "Minimally Invasive Orthognathics Algorithm" that summarizes the overall concept to enhance the Quality of Live (QoL) of patients with maxillofacial deformity undergoing orthognathic/orthofacial surgery is presented.

General Considerations About Minimally Invasive (MI) Surgery

Minimally Invasive (MI) surgery is described as a discipline that involves a "novel way" to perform operative procedures, with the main goal of decreasing the sequelae of traditional surgical techniques [1]. MI surgical approaches have been incorporated in different medical surgical fields, being considered effective in both decreasing patient morbidity and improving esthetic results [1–4]. Thoracic surgery, neurosurgery, and feet and hand surgery are some examples of different areas in which MI surgical techniques were initially developed and published in the scientific literature [5–13].

Even though its definition is still considered unclear by some authors, it is usually associated with (1) enhanced and precise preoperative planning, (2) development of dedicated intraoperative techniques and instruments, and (3) specialized postoperative care. In this regard, endoscopically assisted surgery, piezosurgery, and intraoperative navigation are frequently mentioned as important tools to perform MI surgeries as well [3].

In recent decades, MI surgical approaches became "state-of-the-art" when it comes to patient recovery and quality of life (QoL) during the postoperative period, since the wide range of possible applications can significantly help to prevent complications and allow the achievement of treatment goals in a safer, faster and more gentle manner [3]. By reducing soft tissue trauma and decreasing overall patient morbidity, the concept of MI surgery has been encouraging patients who were until recently reluctant and even averse to any kind of surgical procedure. The main reasons are that the recovery time is also shorter and considered much more comfortable regarding edema, bleeding, and pain [14] in comparison to conventional surgical approaches.

In general terms, MI techniques are normally associated with smaller incisions, tunneling techniques to avoid extensive degloving of soft tissues, and decreased operating time, consequently enhancing the quality of tissue healing, reducing the risk of infection, and improving the whole postoperative experience.

F. de O. Andriola (✉)
Department of Oral and Maxillofacial Surgery, Hospital São Lucas, Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre, Rio Grande do Sul, Brazil

Andriola Odontologia, Porto Alegre, Rio Grande do Sul, Brazil
e-mail: fernando.andriola@pucrs.br

Y. Weinberg
Oral and Maxillofacial Surgery Division of Surgery, Barzilai University Medical Center, Ashkelon, Israel
e-mail: yves@bmc.gov.il

G. R.J. Swennen
Division of Maxillofacial Surgery, Department of Surgery, AZ Sint-Jan Brugge-Oostende AV, Belgium, Bruges, Belgium
e-mail: gwen.swennen@azsintjan.be

G. R.J. Swennen (ed.), *Minimally Invasive (MI) Orthognathic Surgery*, https://doi.org/10.1007/978-3-031-38012-9_1

Minimally Invasive (MI) Orthognathic Surgery

Likewise in other surgical fields, MI techniques were developed and are currently used in several Oral and Maxillofacial Surgery (OMFS) procedures. MI surgery was first introduced in OMFS through the development of endoscopic-assisted surgical approaches to treat salivary gland diseases, especially sialolithiasis [15–21].

By using less invasive techniques, the morbidity and some inherent complications following conventional surgical procedures of the parotid and submandibular glands (e.g., facial scars, nerve damages, numbness, and salivary fistulas) could be successfully reduced [21]. Meanwhile, the endoscope started being used for other surgical approaches, such as in neurological facial surgery [22, 23] and temporomandibular joint (TMJ) arthroscopy [24–28].

Moreover, different MI techniques to treat TMJ disorders (TMD) were developed, such as arthrocentesis and arthroscopic TMJ surgery [29–31]. Additionally, MI surgical techniques to treat condylar [32, 33] and other facial traumas, such as orbital fractures [34–36] were introduced.

Besides the endoscopic-assisted techniques, intraoperative navigation, [37–39] distraction osteogenesis, [40, 41] and tissue engineering [42, 43] have also been described as alternatives to minimize patient morbidity. Although each of the latter technologies certainly provides specific advantages, special attention always needs to be paid to guarantee that their implementation will not extensively increase the overall surgical time, which would be a drawback toward the MI surgery philosophy.

Toward orthognathic surgery, several MI techniques have been described and evaluated throughout the last decades, as described below (Sects. "Background of MI Orthognathic Surgery" and "MI Orthognathic Surgical Techniques").

Background of MI Orthognathic Surgery

MI orthognathic surgical techniques have been developed to minimize patient morbidity in relation to the conventional more "wide-open" approaches, aiming to reduce surgical operating time, intraoperative bleeding, trauma to the soft tissues, and postoperative discomfort [3].

Scientific evidence has shown that patients undergoing orthognathic surgery using small incisions and minimal dissection have less morbidity and present a faster postoperative recovery after different orthognathic procedures, [3, 4, 44] such as surgical-assisted rapid palatal expansion (SARPE), [45–48] Le Fort I, [46, 49, 50] sagittal split, [51–53] and chin [54] osteotomies. Together with the improved clinical outcome and patients' positive feedback, the traditional philosophy of "Big Surgeons, Big Incisions", which for decades has guided surgical training and operation routine around the world, is gradually changing.

Table 1.1 "Minimally Invasive (MI) Mindset" parameters toward MI orthognathic surgery

• Use of MI surgical techniques.
• Small[a] incisions.
• Less subperiosteal degloving.
• Care and protection of soft tissues.
• Gentle retraction.
• Delicate instruments.
• Avoid unnecessary tissue trauma.
• Surgical efficiency (decreasing surgical operating time).

[a]As small as possible, but big enough to provide an adequate safe access and avoid lacerations

The "less-degloving mindset" and enhancement of surgical efficiency are meanwhile considered as the key parameters toward decreasing postsurgical discomfort and shortening of the rehabilitation period of patients undergoing orthognathic surgery [3].

The main parameters to perform orthognathic surgical procedures following a "Minimally Invasive (MI) Mindset" based on the scientific literature [3] are summarized in Table 1.1.

MI Orthognathic Surgical Techniques

According to AlAsseri and Swennen, [3] there is evidence in the scientific literature supporting that the application of MI techniques in orthognathic surgery is considered safe, feasible, and effective. Nevertheless, despite the reported distinct benefits of the available techniques, the steep surgical learning curve, operating time, and costs are important factors that should be considered before their routine clinical application.

Several studies that describe and evaluate different MI orthognathic approaches have been published. In 1990 decade, Morselli [45] described a less traumatic technique toward the maxillary osteotomy used in surgically assisted rapid palatal expansion (SARPE) where no mucosal incision or mucoperiosteal reflection was necessary. The author used only a 2-mm osteotome to perform the midline, the horizontal, and the pterygomaxillary sutures osteotomies. A very high success rate was reported, and all 24 patients presented a rapid postoperative recovery with less postoperative pain. Regarding the incision length and the extent of degloving in different orthognathic surgical procedures, no significant changes were reported until Hernández-Alfaro et al. [47, 50] described a limited approach toward SARPE and the Le Fort I osteotomy through small buccal incisions followed by limited dissection. In the SARPE technique, pterygomaxillary

(PTM) disjunction was performed under intravenous (IV) sedation through the "twist technique" by using a wide osteotome. For the Le Fort I, no significant neurovascular complications were recorded, and early hospital discharge was achieved for both mono- and multi-segmental osteotomies, effectively down fracturing the maxilla and allowing adequate visualization of the anatomy during surgery. No additional surgical operating time was required in comparison to conventional SARPE and Le Fort I approaches to successfully treat two large series of patients. During the Le Fort I osteotomy, piezoelectric surgery was also used to remove bone interferences from the posterior palatine neurovascular bundle. In order to perform a mandibular midline osteotomy, a vertical labial incision was described by Nadjmi et al. [54] as an interesting approach, avoiding an extended horizontal incision through the mentalis muscles. The short vertical midline incision in the lower lip frenulum was considered sufficient to provide an adequate access to the symphyseal region.

Nevertheless, it is important to keep in mind that using a small incision does not necessarily mean that the surgical procedure will be less traumatic, since it still needs to be big enough to allow an adequate and safe access to the region of interest. In this regard, besides a conservative incision, appropriate surgical instruments as well as correct handling of the surgical wound and surrounding soft tissues also have an essential role, being even more important than the size of the incision itself. In summary, the incision should be "as small as possible, but big enough" to avoid excessive traction on the soft tissues and to allow a safe osteotomy and accurate stable rigid internal fixation. Otherwise, what is supposed to be an "advantage" can easily become a "drawback" by increasing the procedure's difficulty and causing even a bigger trauma than the conventional orthognathic approaches.

Keep in Mind

The incision must be "as small as possible, but big enough" in order:

1. To provide an adequate and safe access.
2. To avoid potential lacerations by excessive traction on the soft tissues.

Although small incisions, minimal dissection, and degloving are the keystones of MI surgical techniques, the use of endoscopes, piezoelectric instruments, and intraoperative navigation have proven to be important tools toward MI surgery in various surgical specialties [3, 21]. Nevertheless, there is also still controversy in the literature regarding the longer duration, complexity, and steep learning curve of implementing some of these techniques into the daily clinical routine [3].

Evidence-based literature supports that the endoscopic approach can have an important role in MI surgeries since it facilitates the use of smaller incisions, reduced subperiosteal degloving, and provides additional magnified visualization [2]. Endoscopic approaches and its advantages were described for the main orthognathic surgical techniques, in sagittal split osteotomies (SSO), intraoral vertical ramus osteotomies (IVRO), and in the treatment of condylar hyperplasia or idiopathic condylar resorption [55]. Toward the IVRO, for example, it gives the surgeon the possibility to better visualize the lingula (*Spix spine*) to properly control the vertical osteotomy from the sigmoid notch to the inferior mandibular border. Also, the distal and proximal segments and potential bony interferences in between can be better visualized [56]. Toward Le Fort I osteotomies, the use of endoscopic instruments allowed a safe separation of the pterygomaxillary suture through smaller incisions, [57] also being useful as a visual guidance in SARPE procedures. Mommaerts et al. [48] published an innovative endoscopic-assisted endonasal Le-Fort I corticotomy procedure toward Transpalatal Distraction (TPD).

Regarding the operating time spent, however, there is still no consensus since some authors have found an increased surgical time [46] while others found no significant reduction in overall operating time [48] in comparison to conventional surgical approaches. All authors, however, described a significant reduction in postoperative edema and recovery time [3]. Therefore, it has been recommended that prior to clinical application, inexperienced surgeons start endoscopic handling and training on human or animal cadavers to ensure an adequate level of expertise [49, 51].

Ultrasonic or piezoelectric devices are other useful tools with proven efficacy toward bone cutting with soft tissue preservation, higher precision and control, and the capacity to provide a clean operating field due to its cavitation effect and its micromovement system [58, 59]. With the growing interest in MI orthognathic surgical techniques, the piezoelectric osteotome has been used as an excellent alternative to perform more conservative osteotomies in Le Fort I, [60] SARPE, [61] and mandibular surgical approaches [62]. The surgical operating time, blood loss level, neurosensory complications, and postoperative pain have been assessed as the main factors to determine how efficient and beneficial piezosurgery can be in orthognathic surgery. Similarly to the endoscope, there is no consensus regarding the effect on surgical operating time using piezoelectric instruments. While some studies report no difference, [63–65] other authors defend both the increase [66–70] and decrease [71] of overall operating time. In addition, blood loss was considered to be significantly less in five comparative studies when piezosurgery was used, [63, 64, 66, 70, 72] in contrast to another study [65] that found no difference when comparing the

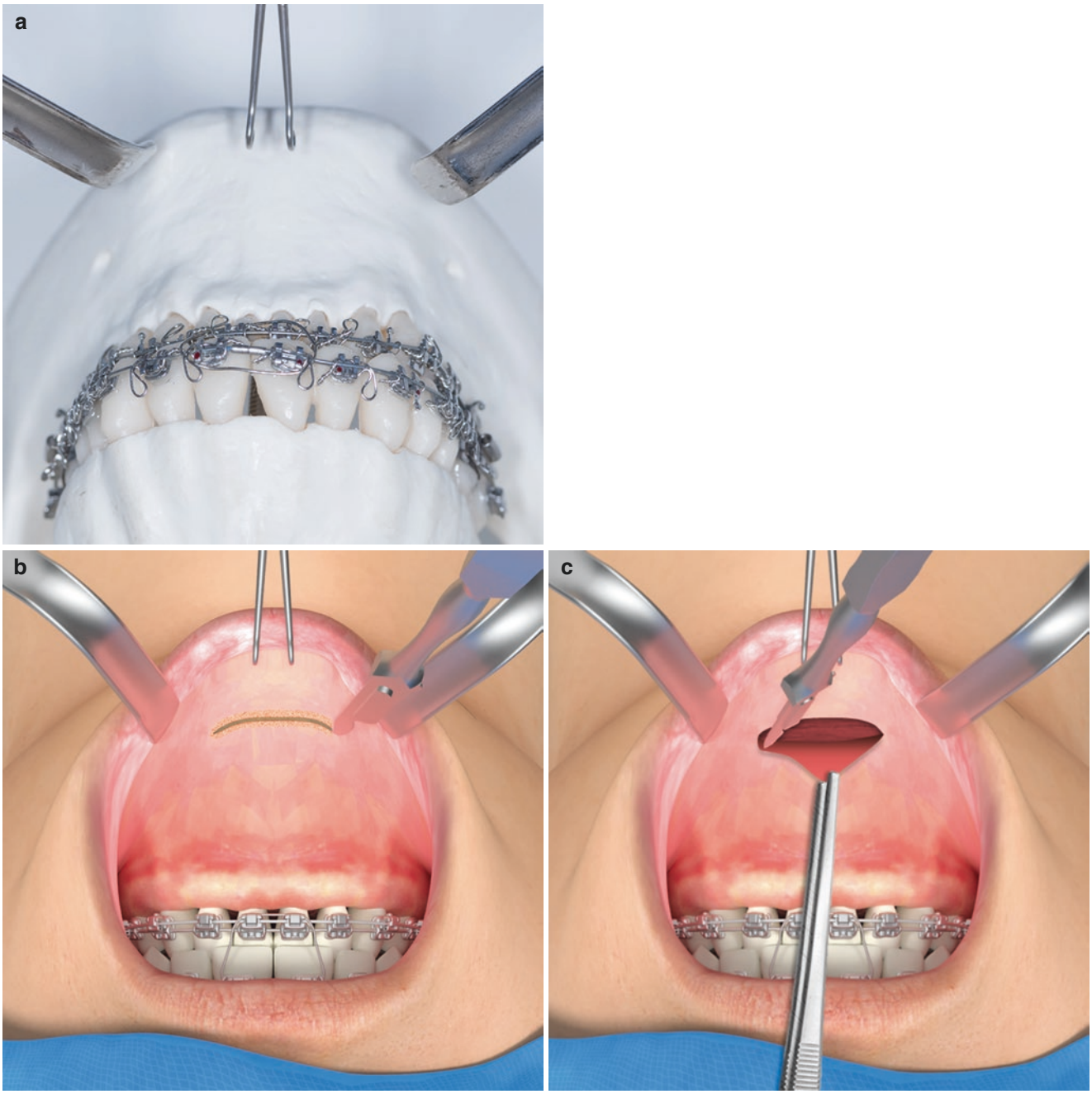

Fig. 3.3 The MI soft tissue approach to the chin (Step 1) and positioning of the MI orthognathic instruments (L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany) are shown on a synthetic skull (**a**) and graphic illustrations (L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany; modified by FOA) (**b**, **c**). Note the high mucosal curved incision in the lower lip (**b**) and the submucosal sharp dissection of the vestibular flap (**c**). Clinical pictures made by ©Valérie Swennen Boehlen. All rights reserved

Step 2—MI Access toward the Bony Chin

On request of the "Operating Surgeon", "Assistant 1", and "Assistant 2" remove all MI instruments from the patient's mouth. The "Operating Surgeon" now supports the chin from below with his left hand (Fig. 3.5a–c) and keeps it in the horizontal plane while incising the deep soft tissue layers through the mentalis muscles and the periosteum until the bone using the same #15 scalpel. The deep-layer incision is performed approximately 5 mm below the mucosal incision, in order to create a good muscle bulk for appropriate double-layer closure of the wound (Fig. 3.5c). The length of the deep incision is slightly shorter than the superficial mucosal incision, approximately 15 mm, and centered on the midline.

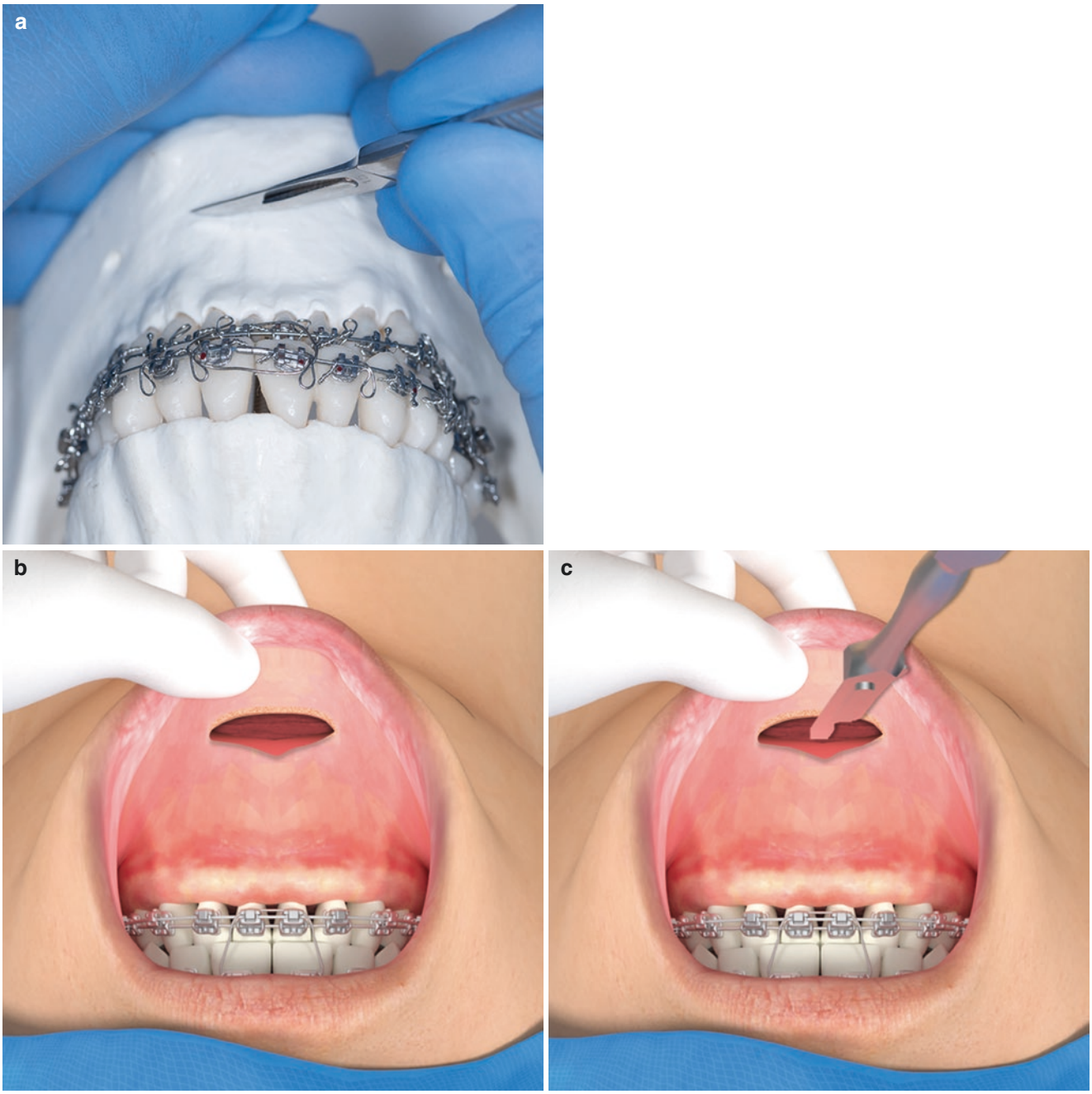

Fig. 3.5 The MI access toward the bony chin (Step 2) is shown on a synthetic skull (**a**) and on graphic illustrations (L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany; modified by FOA) (**b**, **c**). Note that all MI instruments have been removed, so that the right-handed "Operating Surgeon" can support the chin and hold the lower lip with his left hand in order to perform the deep-layer incision through the mentalis muscles and periosteum with his right hand. Clinical picture made by ©Valérie Swennen-Boehlen. All rights reserved

After reaching the inferior border, the "Operating Surgeon" turns the MI1 raspatorium approximately 45 degrees to the right side (Fig. 3.7a) to create a subperiosteal pocket around the chin border in order to position a chin retractor (Ch1). Note that at this time no other MI instrument is in the patient's mouth.

The "Operating Nurse", who is perfectly aware of the "MI Chin operating sequence" due to the dedicated "MI Chin surgical sequence template bars" (Sect. "General Considerations regarding the "MI Chin Osteotomy" Surgical Procedure"), now automatically gives the right-handed "Operating Surgeon" the Ch1 retractor correctly in his right

1. Organization of the surgical instrumentation table by the "Operating Nurse" (Sect. ""MI Le Fort I Osteotomy" Instruments and "MI Le Fort I Osteotomy" Surgery Instrumentation Table Organization")
2. Preparation of the patient in the operating room by the "Operating Surgeon", "Assistant 1", and "Assistant 2" (Sect. "Patient and Operating Room Preparation Toward the "MI Le Fort I Osteotomy" Surgical Procedure")

"MI Le Fort I Osteotomy" Instruments and "MI Le Fort I Osteotomy" Surgical Instrumentation Table Organization

In order to improve the efficiency of the overall surgical team during an "MI Le Fort I Osteotomy", "MI Le Fort I surgical sequence template bars" were developed to indicate in a systematic order the required MI coded instruments (L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany) [3] (Chap. 2).

The "Operating Nurse" places the six dedicated "MI Le Fort I surgical sequence template bars" on top of the surgical instrumentation table (Fig. 4.1) which allows a fast, easy, and standardized organization of the relevant MI orthognathic instruments not only at the initiation but also during the entire surgical procedure. Moreover, the "Operating Nurse" is able to follow and knows at any moment which "MI Le Fort I" orthognathic instrument is needed by the "Operating Surgeon", "Assistant 1", and "Assistant 2" to smoothly perform the "MI Le Fort I Osteotomy".

The "Surgical Codes" and "Surgical Sequence" toward the "MI Le Fort I Osteotomy" are mentioned in Table 4.1.

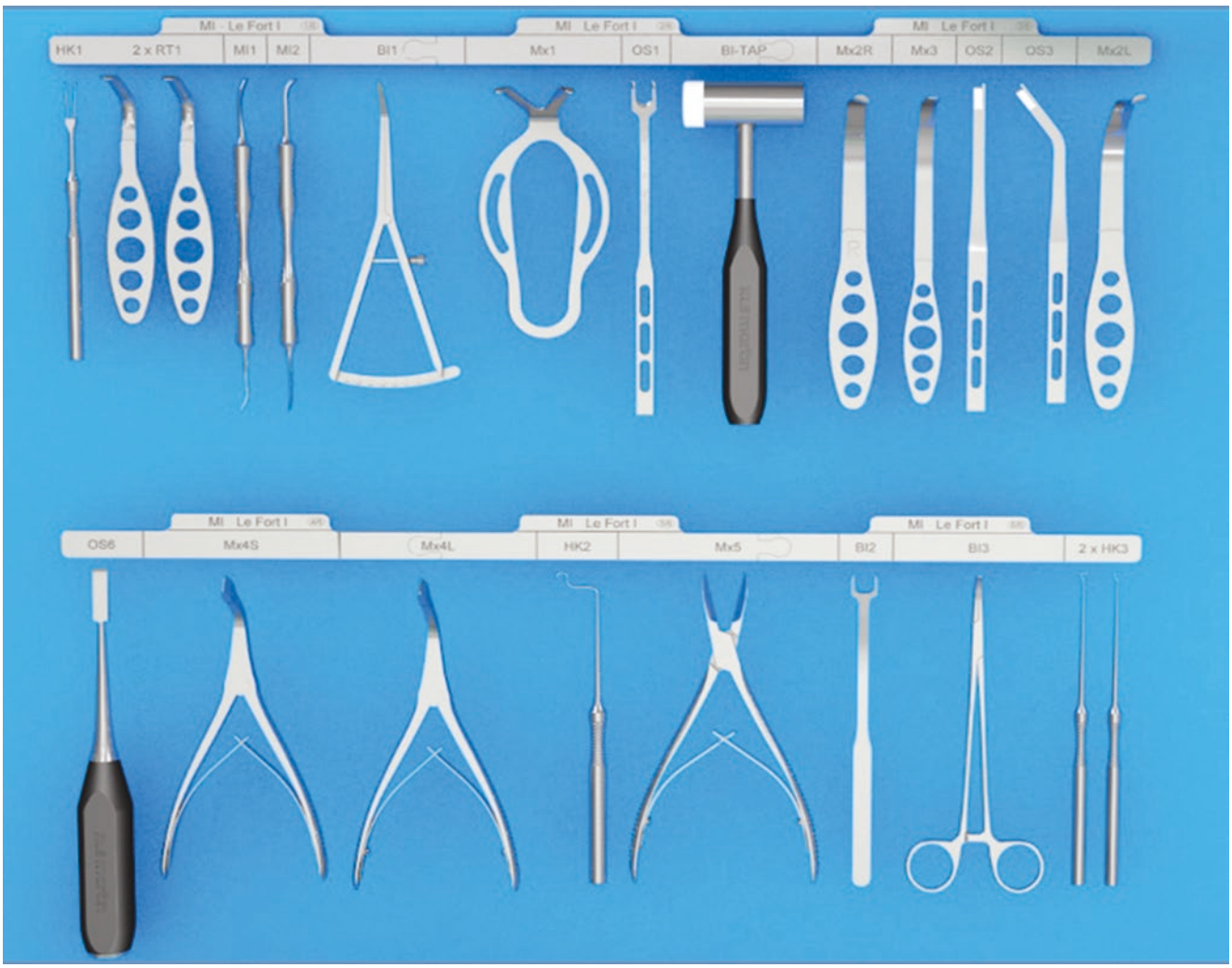

Fig. 4.1 MI orthognathic instruments used to perform the "MI Le Fort I Osteotomy" systematically organized on the surgery instrumentation table by the "Operating Nurse" (graphic illustration from L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany)

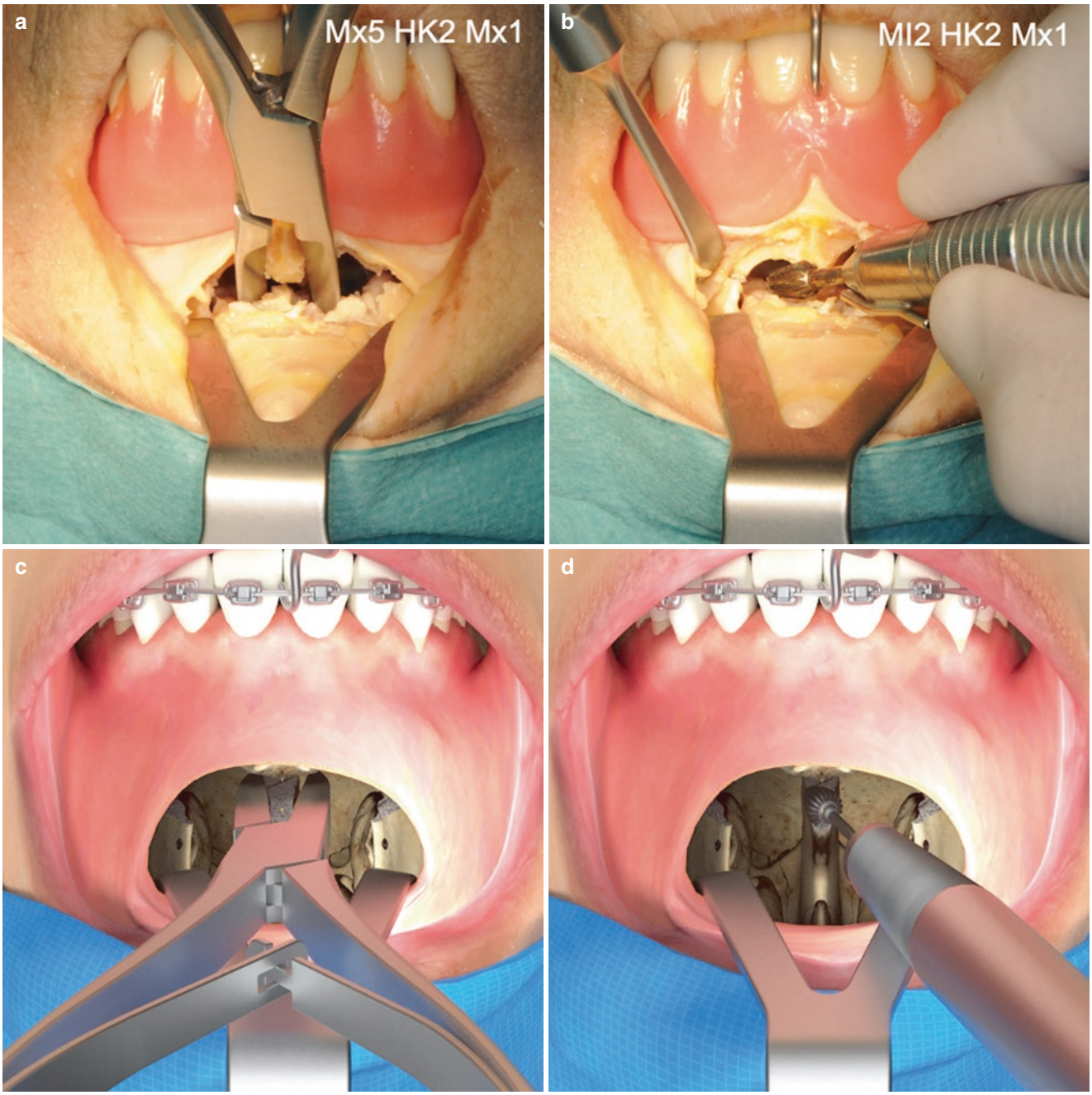

Fig. 4.26 Remodelling of the nasal floor, nasal septum, removal of potential premature bone contacts (Step 9) and positioning of the MI orthognathic instruments (L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany) are shown on a human cadaver (Department of Anatomy and Embryology, University of Maastricht, the Netherlands) (**a**, **b**) and graphic illustrations (L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany) (**c**, **d**). Note that the HK2 hook may be placed on the upper dental orthodontic wire but preferably on the maxillary bone in order not to detach the upper braces. Clinical pictures made by

Subsequently, if indicated, reduction of the cartilaginous nasal septum can be performed. After incision with a #15 scalpel, the surrounding nasal mucosa is degloved by the "Operating Surgeon" using the small part of the double-sided sharp MI1 raspatorium, and the lower part of the septum is reduced with the Mx5 septum scissors.

Tip

The Anterior Nasal Spine (ANS), being one of the nasal tip supporting mechanisms can be remained untouched, reduced, completely removed or reshaped depending on the intended clinical effect of the MI Le Fort I on the nose.

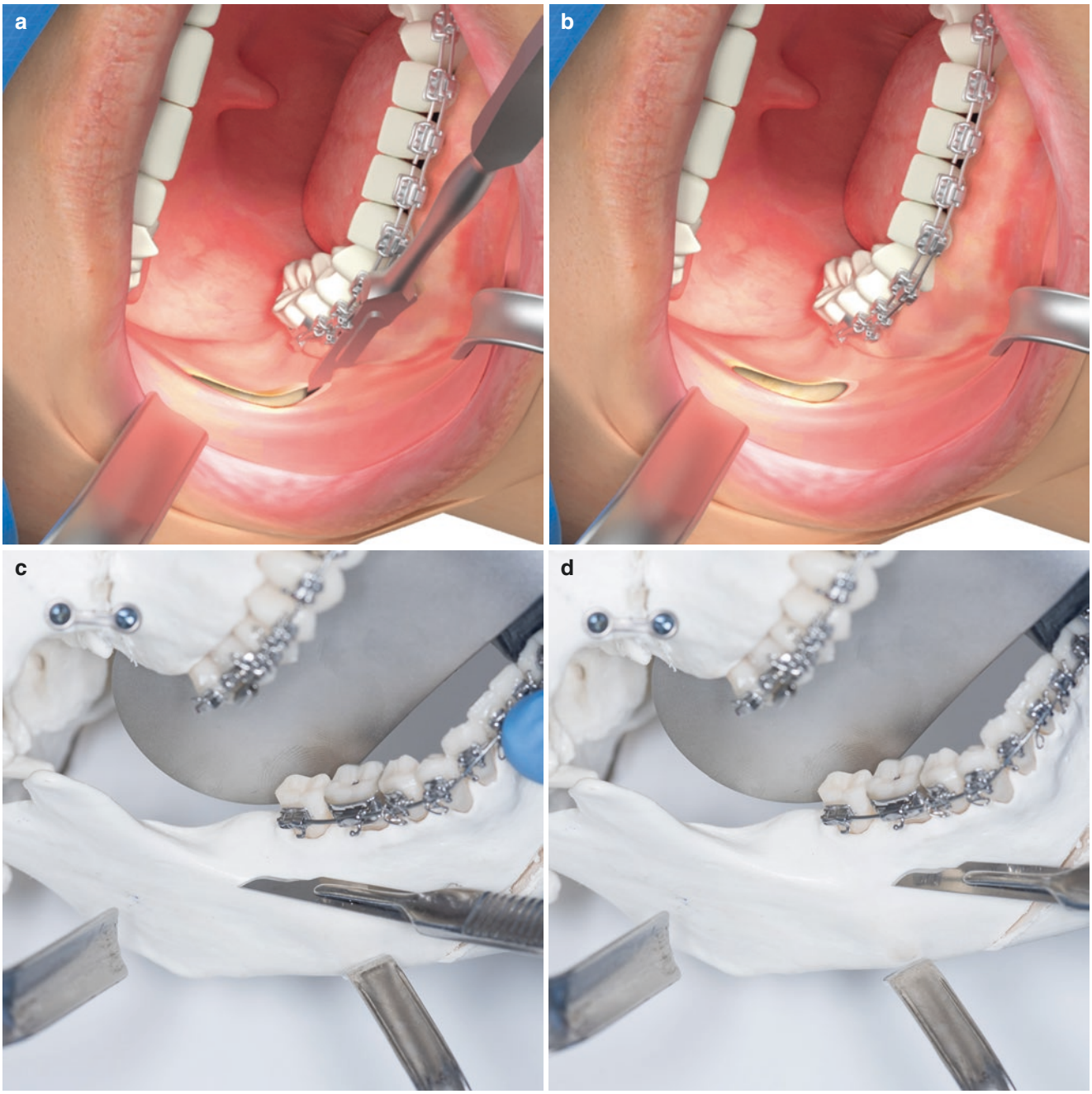

Fig. 5.3 The MI soft tissue approach to the sagittal split osteotomy (SSO) of the mandible (Step 1) and positioning of the MI orthognathic instruments (L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany) are shown on graphic illustrations (L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany) (**a**, **b**) and a synthetic skull (**c**, **d**). Note the change of the #15 scalpel which is orientated 90 degrees to the bone once it reaches the distal side of the second molar toward the mesial side of the first molar. Note that "MI Chin" (Chap. 3) and "MI Le Fort I" (Chap. 4) osteotomies were already performed. Clinical pictures made by ©Valérie Swennen-Boehlen. All rights reserved

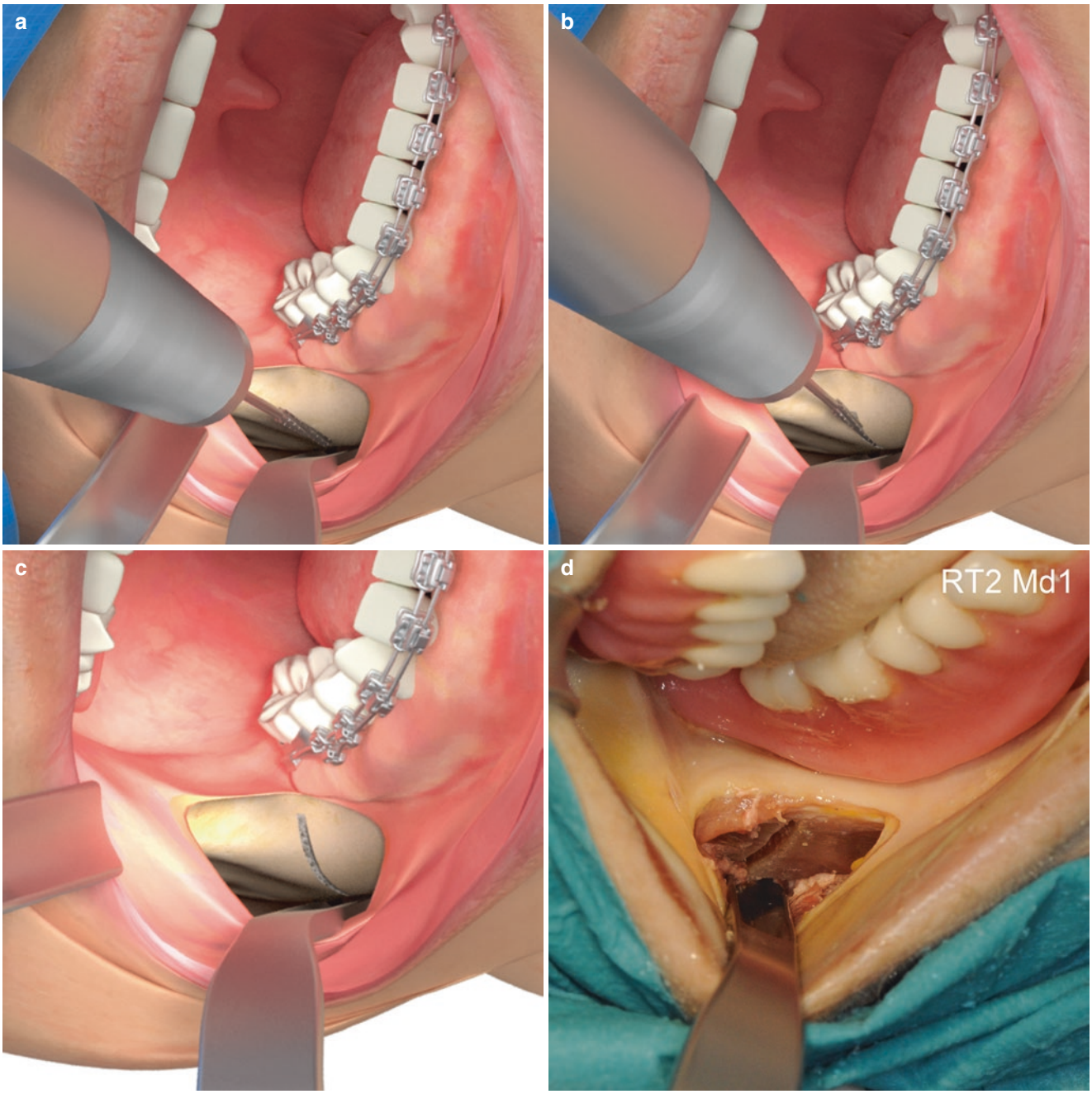

Fig. 5.10 The MI buccal corticotomy of the right horizontal mandibular ramus (Step 3) and positioning of the MI orthognathic instruments (L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany) are shown on graphic illustrations (L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany) (**a**–**c**) and on a human cadaver (Department of Anatomy and Embryology, University of Maastricht, the Netherlands) (**d**). Note the angulation of the Lindemann burr (**a**, **b**) and buccal corticotomy (**c**, **d**). Note that according to surgeon's preferences, a reciprocating saw can also be used. Clinical picture made by ©Valérie Swennen-Boehlen. All rights reserved

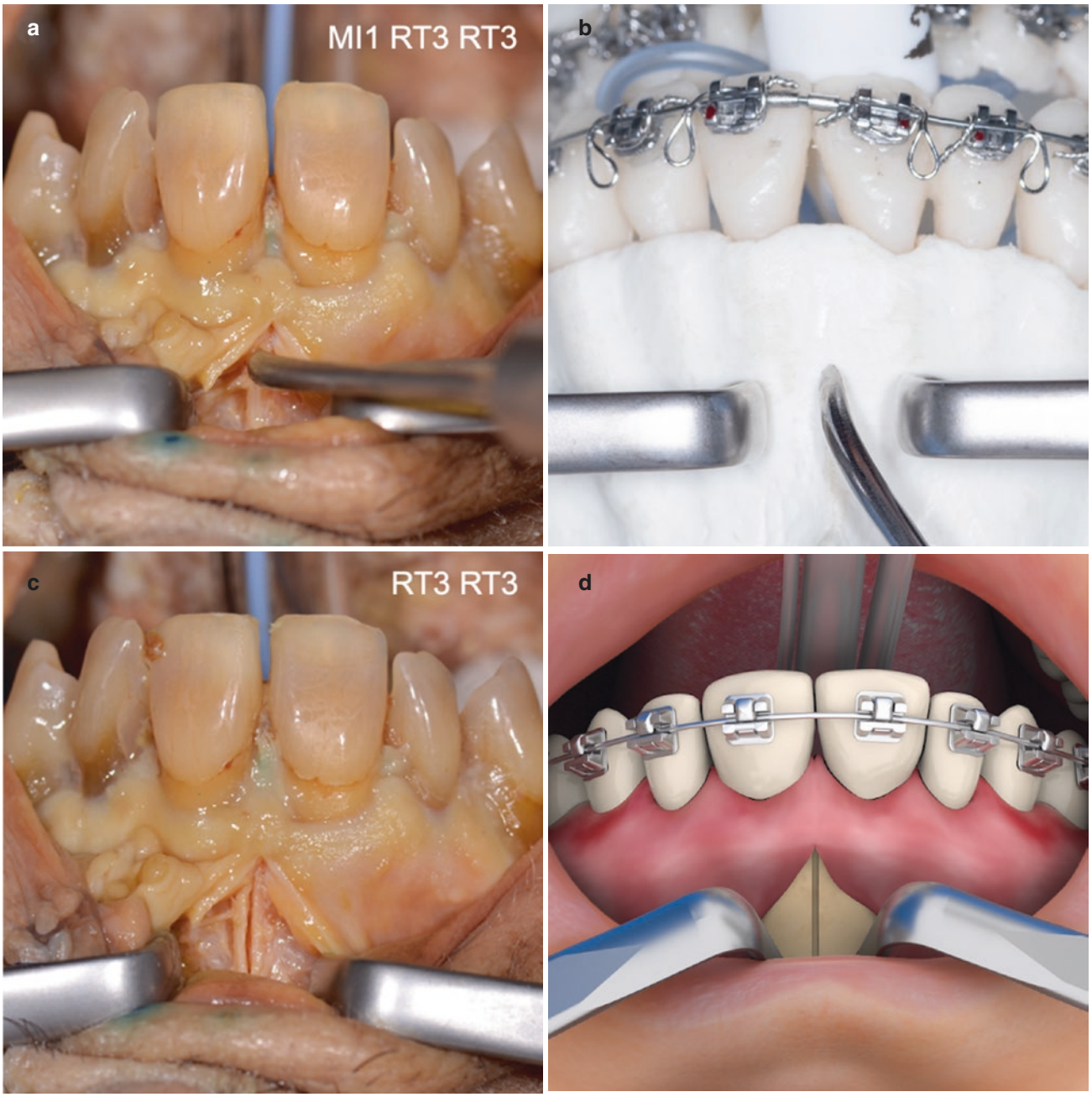

Fig. 6.17 Marking the skeletal maxillary midline toward the upper dental midline (Step 7) and positioning of the MI orthognathic instruments (L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany) are shown on a human cadaver (Department of Anatomy and Embryology, University of Maastricht, the Netherlands) (**a**, **c**), a synthetic skull (**b**) and a graphic illustration (L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany) (**d**). Note that the small part of the sharp double-sided MI1 raspatorium is used to identify the anterior vertical intermaxillary midline suture without the use of a burr or a piezo device. Clinical pictures made by ©Valérie Swennen-Boehlen. All rights reserved

riorly and continued posteriorly as a green-stick fracture, followed by its mobilization.

While "Assistants 1 and 2" continue to gently retract the soft tissues with the small RT3 soft tissue retractors placed on the bone in the small wound, the "Operating Surgeon" places his left middle finger intra-orally at the anterior region of the hard palate. He then inserts with his right hand the thin straight OS4 osteotome with a 45-degree angle into the previously deepened anterior vertical intermaxillary suture at the dentoalveolar ridge in between the two upper central incisors (Fig. 6.18a–d). On the instructions of the "Operating Surgeon", "Assistant 2" now performs single taps on the thin straight OS4 osteotome using the metal part of the BI-TAP mallet with his right hand, while "Assistant 1" performs fine aspiration. After a few taps, when the dentoalveolar bone is fully osteotomized and separation between the upper central

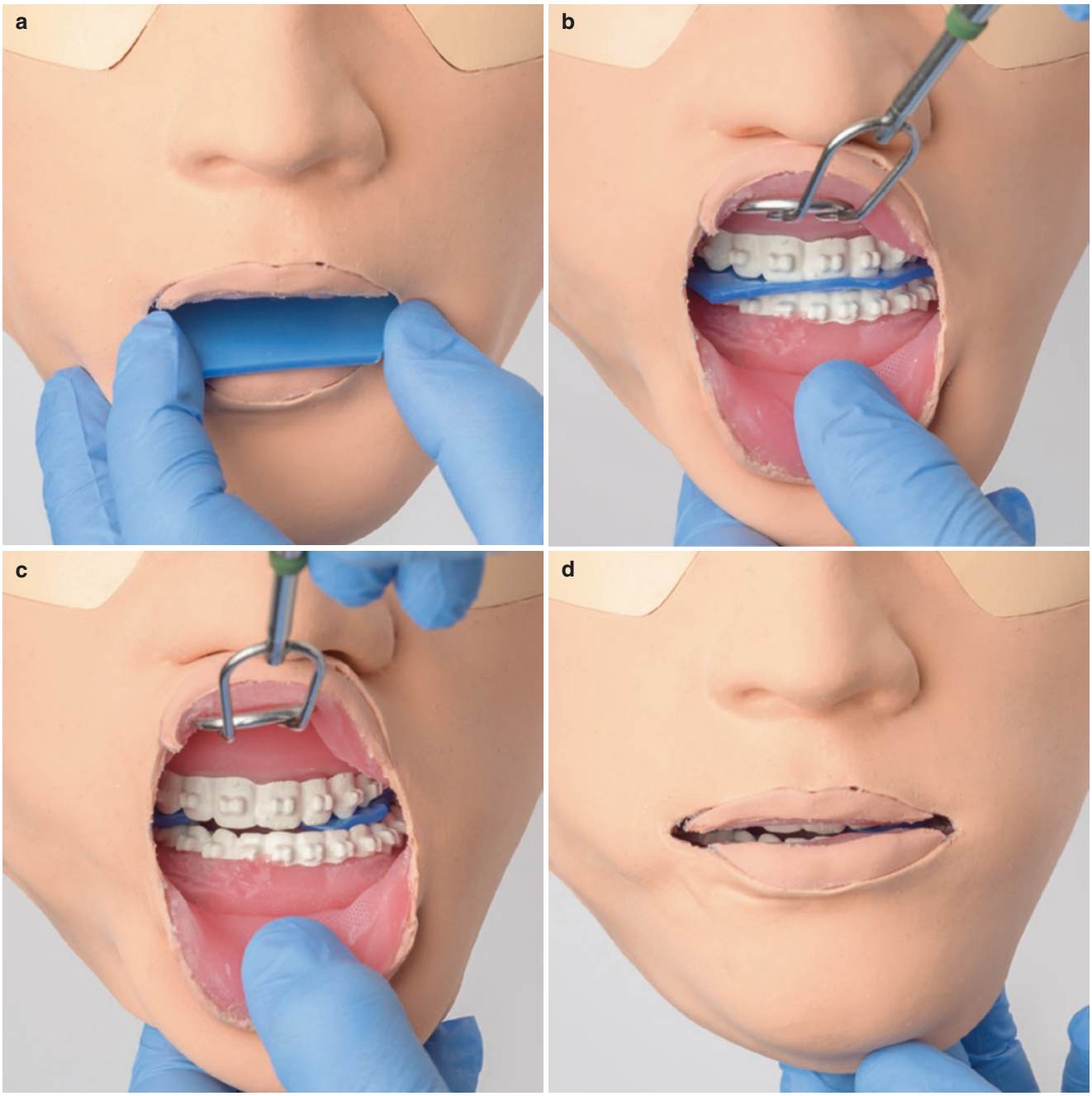

Fig. 8.5 Didactic illustrations on a phantom model (L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany) show wax bite registration (bite registration sheet wax, Almore International, Hickory, USA) in centric relation (CR) (**a**, **b**) and additional trimming of the wax bite to avoid distortion of lip posture and morphology (**c**, **d**). Pictures made by ©Valérie Swennen-Boehlen. All rights reserved.

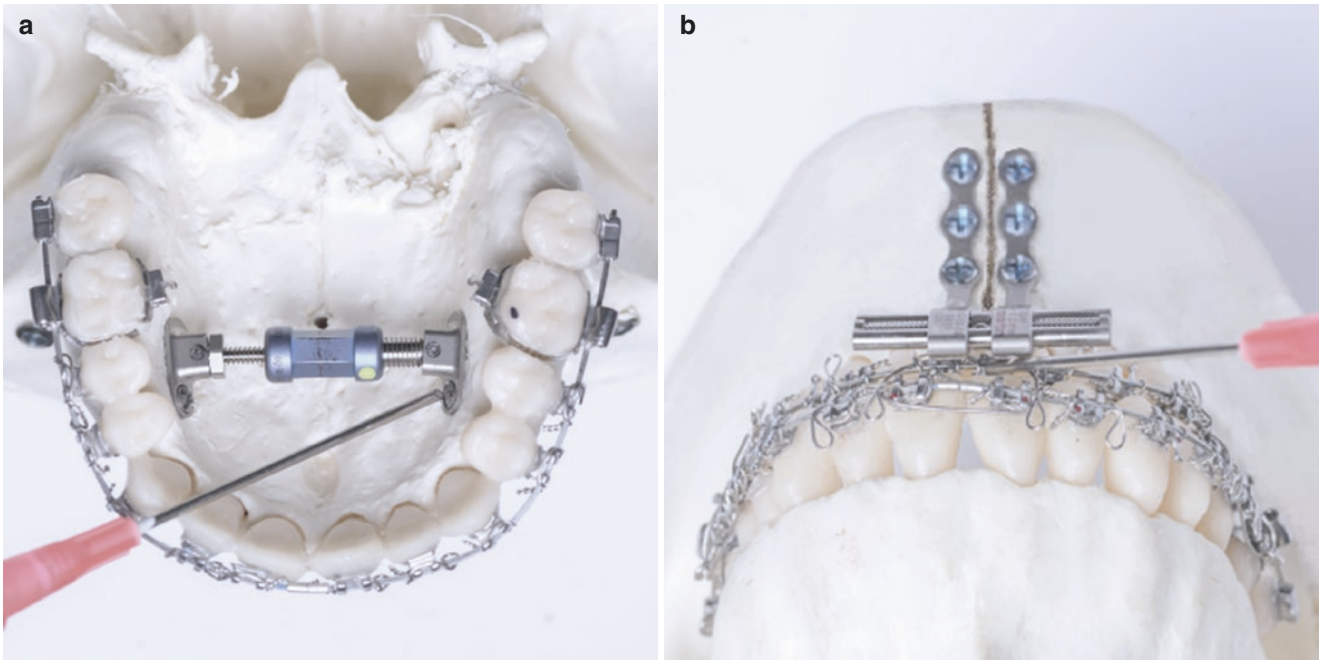

Fig. 8.12 Didactic illustrations on a synthetic skull show topical application of chlorhexidine gel: (**a**) at the abutment plates of a bone-borne maxillary expansion apparatus (L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany) and (**b**) in between the lower incisors after installation of a bone-borne mandibular expansion apparatus (L1® MI Orthognathics, KLS Martin, Tuttlingen, Germany). Pictures made by ©Valérie Swennen-Boehlen. All rights reserved

Prior to extubating the patient by the "Anesthesiologist", inter-arch guiding elastics are placed to guide the patient's final and new occlusion (Fig. 8.13) for the first week until the patient is seen after 1 one week by the "Operating Surgeon" for follow-up (Sect. "Patient Follow-Up"). The inter-arch guiding elastics are typically placed laterally along the perioperative jaw movements with an additional elastic in the frontal region to avoid immediate postoperative tongue interposition (Fig. 8.13a).

Tip
Inter-arch guiding elastics are placed prior to extubating of the patient to guide the final new occlusion. In case of an Anterior Open Bite (AOB) deformity, the front elastic is placed on additional skeletal anchorage in the alveolar region of the upper and lower dental midlines.

After applying inter-arch guiding elastics, orthodontic wax is placed on the orthodontic braces from canine to canine at the lower (Fig. 8.13c) and/or upper dental arch in case of a "MI Chin Osteotomy" or "MI Le Fort I Osteotomy", respectively, in order to protect the mucosa and to enhance postoperative comfort.

Consecutively, the patient's face is cleaned with saline (NaCl) solution, dried and after application of an ether solution at the nasolabial and labiomental regions, suture strips are placed to properly define the new nasolabial angle and/or plica labio-mentalis, to prevent dead space and to apply postoperative compression for one week after surgery. In case of a "MI Le Fort I Osteotomy", small 5 mm suture strips are applied at the level of the subnasale landmark to define the nasolabial angle (Fig. 8.14).

In case of a "MI Chin Osteotomy", small 5 mm suture strips are applied to define the new plica labio-mentalis (Fig. 8.15a) or large 10 mm suture strips (Fig. 8.15c) to stretch it in regard to the patient's individualized treatment plan. Subsequently, an overlying chin compression bandage is applied using large 10 mm suture strips (Fig. 8.15b, d).

Finally, a steroid ointment (Elocom ® 0.1%, NV Schering-Plough Labo, Heist-op-den-Berg, Belgium) is applied on both lips to reduce postoperative swelling (Fig. 8.16a).

Pain, Nausea, and Vomiting Management

In addition to the measures described in this chapter to reduce pain after MI orthognathic surgery such as MI surgical techniques, local anesthesia prior to surgery (Sect.