H. W. Anselm Wiskott

FIXED PROSTHODONTICS

PRINCIPLES AND CLINICS

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Foreword

This book was written for dental students. It is intended to guide the prospective practitioner towards a scholarly approach to clinical problems. As such, it deals with the principal concepts and clinical steps of fixed prosthodontics.

The text was laid out to provide the reader with a broad view of the field and then concentrate on the essentials of restorative dentistry using fixed prostheses. It also involves the interrelationships between basic sciences (as discussed in Oral Environment), the clinical disciplines of periodontics, orthodontics, operative dentistry and implantology (in Preprosthetic Phase) and the realm of fixed prosthodontics (in Prosthetic Phase). In the chapters we will discuss the scientific background first and then move to clinical applications. In analogy with other human endeavors, prosthetic dentistry can be conducted at the strategic, the operational and the technical levels. We will address all three levels, but qualified as follows. First it is recognized that while the underpinning scientific evidence is quite homogenous, the strategic options at the planning stage are often numerous. This equally applies to the operational decisions during the development of a treatment sequence and to the technical level, that is, the clinical techniques applied during execution. Second, a textbook should be both a learning and a teaching aid, thereby implying that it must provide the teacher with something to teach. It is therefore recommended that the workflows described in the clinical sections be adapted to optimally suit individual needs. Third, the present text does not recommend any specific brands but only describes procedures using generic terminology. This acknowledges the availability of many products of superior quality without the need for an author to direct the clinician to a specific make.

Besides the scientific background and the clinical steps, many chapters also include a historical perspective on the topics presented. As a medical discipline, Dentistry has a long and distinguished history in which a host of researchers and clinicians built the body of evidence that supports contemporary scientifically-based treatment options. In this author's opinion, paying tribute to our predecessors and acknowledging their merits should be part of an academic approach to dental education.

Texts that aim at conveying organized knowledge must be laid out in a methodical fashion. The subject matter and the terminology must be introduced to the reader in an orderly sequence. In this regard, attention was focused on structuring the chapters so that later chapters build upon the information that was provided in earlier sections. In line with to this principle, the text is abundantly cross-referenced. In the few instances where breaks were included into logical sequencings, those are clearly indicated to the reader.

This text aims at conveying sometimes arduous and complex notions to clinicians in the early phases of their professional development. At times this may require that first order approximations be made and that not all idiosyncrasies, exceptions, or clinical intricacies be considered individually – there is a limit to the amount of information that can be included in a chapter without blurring the message. Also, the author considers himself a friend of proper terminology. Therefore whenever applicable, the Glossary of Prosthodontic Terms will be used as reference – streamlining terminology helps in avoiding confusion and misunderstanding. Still, terminology should not be unnecessarily complex – referring to 'airborne particle abrasion' for a process which the entire world calls 'sand-' or 'grit-blasting' imposes unnecessary wordiness to the reader. Similarly, denoting an artificial crown by the word string 'single unit fixed dental prosthesis' may be correct according to some authorities but needlessly burdens a text. Further, whenever applicable, the reader will be provided with synonyms for a given term. 'Synonym' is used throughout as it is understandable to the broad readership, although 'alias' or 'AKA' ('also known as') might be preferable, as they do not imply a 100% duplication of the meaning but still allow some leeway between the different exceptions.

Principles and clinical situations are all explained using diagrams and it is fully acknowledged that those are idealized views of an often more complex reality. On the upside though, schematic views are ideally suited to direct the reader's attention onto specific elements as extraneous aspects are largely out of focus.

Last, with the exception of chapter 3 (it is difficult to explain color in whiter shades of pale), the artwork is kept in black and white format. This is to reduce printing costs to a bare minimum and to allow a wide distribution of the book among students.

Acknowledgements

First and foremost, I am indebted to my wife Yolande – my companion and friend for many years. Besides being a superb mother to our two daughters, her love and enduring support have been most rewarding. Second, my gratitude is expressed to Drs Marie-Christine and Peter Dulguerov for their indefectible friendship. The friendly working atmosphere in their company has been an enjoyable experience throughout.

This text reflects years of lectures, conversation and debate with teachers, colleagues and friends (not necessarily mutually exclusive). While it would be impossible to name them all, it is the author's wish to acknowledge the direct or indirect contribution of the following individuals.

First, Dr Robert Faucher to whom this book is dedicated for his questioning, his incisiveness and his healthy disrespect for any form of dogma. Then the late Dr Sigurd Ramfjord and Dr Raul Caffesse at the University of Michigan in Ann Arbor. My gratefulness extends to both for developing and maintaining a graduate program in periodontics, of which an important part consisted in conveying the importance of structured literature surveys. I am also indebted to the late Dr Robert Moyers who spent countless hours teaching me the nuts and bolts of orthodontic bracket placement and wire bending. My grateful appreciation is extended to Drs Edith Morrison, Gunnar Svanberg and Walter Loesche for sharing their insights on experimental microbiology. Special thanks also to Dr Joseph Clayton for his rocky but fruitful introduction to occlusal concepts and applications.

The author was fortunate to spend three further years under the guidance of Dr Ralph Yuodelis and Jack Nicholls at the University of Washington in Seattle. The education was both practical and theoretical, and definitively established the relationships between fixed prosthodontics, periodontics and material science and engineering. The teaching staff was knowledgeable, open minded and helpful. My deep gratitude specifically goes to the late Drs Saul Schluger and William Ammons.

A number of other individuals have brightened my professional career. In this regard, I am indebted to Drs Susanne Scherrer and Claude Crottaz for their unyielding support; to the late Dr Jean-Noël Nally and Dr Jacques Holz for demonstrating leadership and steadfastness; to Dr Hans Thiel for introducing me to real world of dentistry, and to Messrs Alwin Schönenberger and Roger Renevey for their meticulous laboratory work. My gratitude is extended to Dr Urs Belser for suggesting that this book be written.

My appreciation also goes to our colleagues at the laboratory of applied mechanics at EPFL in Lausanne, Switzerland.

A variety of websites were used during the writing of this text. Besides "general purpose" sites such as *www.thefreedictionary.com* and *www.wikipedia.org*, a number of other sites devoted to more specific aspects also provided information. The author expresses his gratitude to all those who have selflessly constructed websites to share their knowledge with the internet community (whenever feasible, they are referenced in the bibliography). A special mention goes to Dr Martin Spiller *(www.doctorspiller.com)* for his unconventional approach and refreshing tone when bringing dental medicine to the general public.

Many thanks also to all those who have contributed photographs.

The text is unquestionably more readable due to the editorial changes of Mrs Lotika Singha, who was able to convert the author's convolute, intricate, and at times confused sentences into a phrasal stream that is pleasant to read.

Likewise the friendly support of the editorial staff at Quintessence during the layout and proofreading stages is greatly appreciated.

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About the author

H.W. Anselm Wiskott DMD, MS, MSD, PhD

Dr Wiskott graduated in 1977. After three years of private practice and internship he earned a doctorate in dental medicine. He then transferred to the United States and in 1982 he received a Master of Science degree in periodontics from the University of Michigan. In 1989 he was awarded a Master of Science in Dentistry degree from the University of Washington, specializing in fixed prosthodontics, and in 1998 a PhD degree in biomaterials. Dr Wiskott is the author of about 100 scholarly articles. He teaches and practices dentistry in Geneva, Switzerland. He and his wife Yolande have two daughters: Alexa-Sea and Kim-Aurora.

The Prosthodontic Environment

CHAPTER 1

1.1 Introduction

Today, a large proportion of the aging population is motivated to “stay young”. Besides alluding to physical fitness and attractiveness, this attitude also includes the maintenance of a functional and cosmetically appealing dentition. In this context, losing one or several teeth is a traumatic event and many people experience difficulties in coming to terms with their loss. The immediate consequences of tooth loss are functional (the person is unable to chew or speak properly) as well as cosmetic (facial appearance is adversely affected). In the long term, tooth loss often impairs the person’s self-image, emotional balance, and overall quality of life.

Tooth loss is not a disease per se. Still, it often leads to disabilities of varying degrees of severity. Therefore affected individuals should be considered as persons with a disability who seek a prosthodontist’s help to re-establish the original morphology and functional capabilities of their dentition.

Prosthodontics may be primarily regarded as the discipline of dentistry concerned with the replacement of missing teeth. It is commonly subdivided into *fixed* and *removable prosthodontics*. As the name implies, removable prosthodontics refers to treatment modalities using prosthetic devices that can be removed from the mouth for cleansing and maintenance procedures. Fixed prosthodontics encompasses those modes of treatment in which the replacement teeth are permanently placed in the oral cavity (Fig. 1-1).

The nature of a discipline involving prosthetics (as opposed to regenerative approaches) entails that lost tissues are replaced with artificial substitutes. This in turn implies that ‘alloplastic’, that is, non-biologic, materials

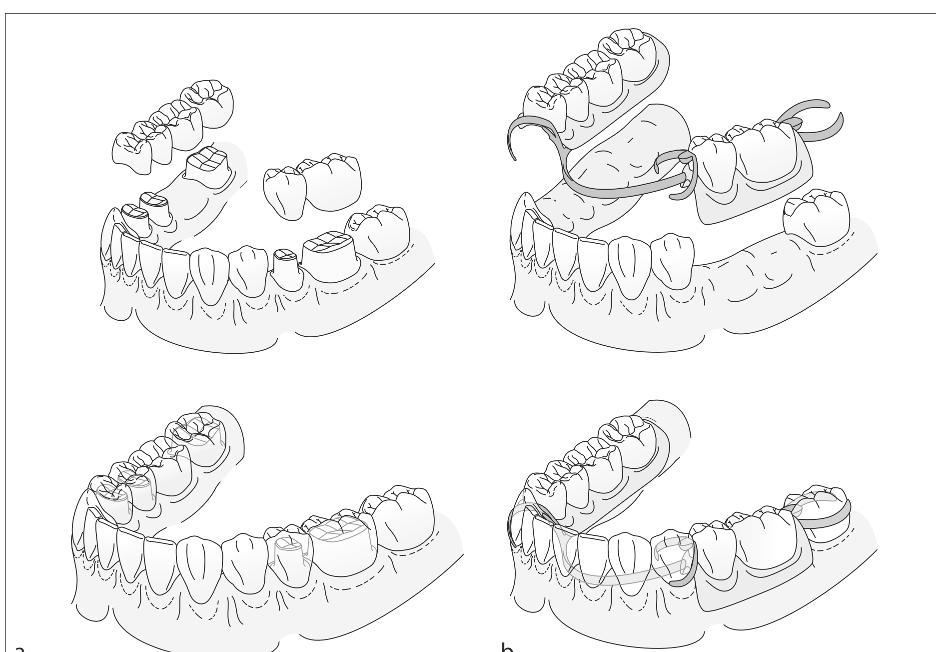


Fig. 1-1a,b Fixed versus removable prostheses
a The classic fixed restoration is permanently cemented onto conically prepared abutment teeth.
b Removable prostheses derive their support from bases and flanges. They are stabilized by clasps on the remaining dental arch segments.

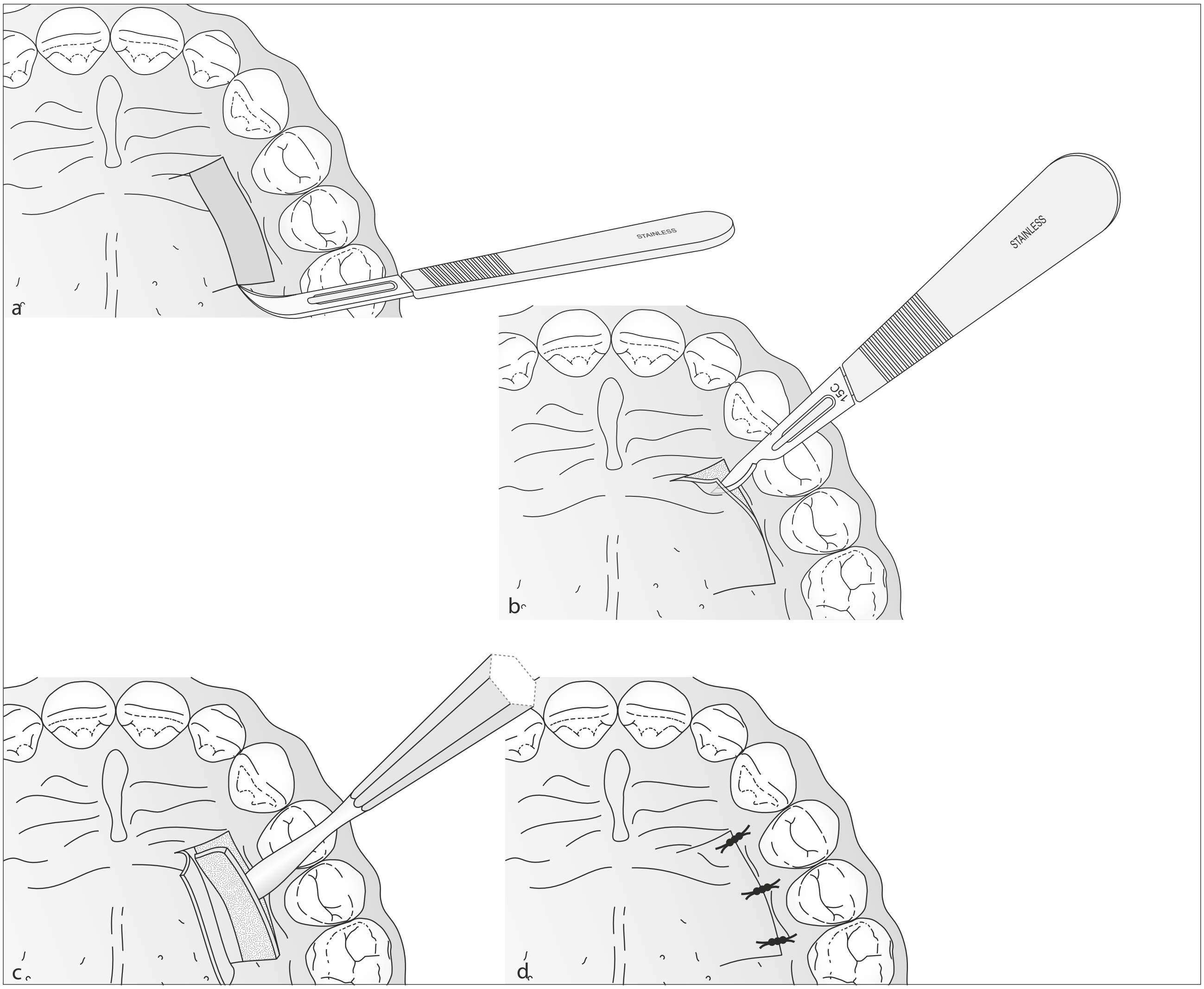


Fig. 8-54a–d Harvest the transplant

a Position the tinfoil and scribe the outline.

b Dissect the superficial mucosa to about 0.5 to 1 mm in thickness. Lift the "trap door".

c Incise to the bone and remove the connective tissue.

d Suture the superficial flap back into place.

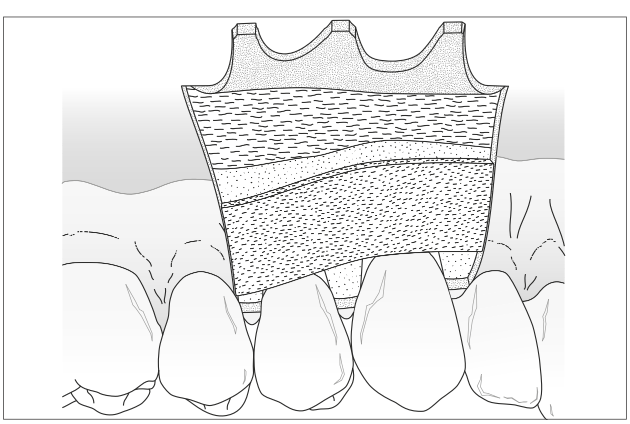


Fig. 8-55 Position the transplant onto the recipient bed

Step #7 Suture the transplant Now suture the transplant onto the bone bed and the roots. Start by passing the needle in palatobuccal direction between the two premolar crowns and place a first bite inside the fibers in the apical aspect of the flap (Fig. 8-56a). The needle is then threaded between the first premolar and the canine and the suture tied on the palatal aspect of the first premolar. Proceed in the same fashion with a second thread, which is centered on the canine (Fig. 8-56b). These sutures should not be overly tight as you do not want to cut off lateral diffusion inside the connective tissue. Their sole purpose is to stabilize the transplant during the initial days of healing. The palatal knots are shown in Figure 8-57b.

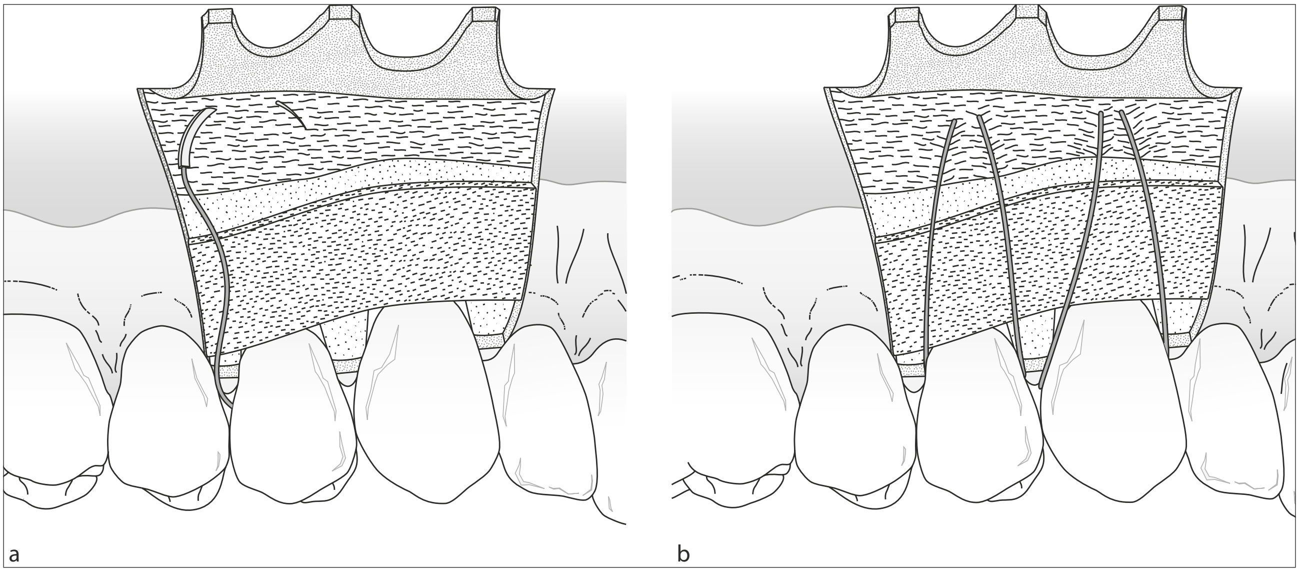


Fig. 8-56a,b Suture the transplant
a Apically the sutures are hooked into the loose fibers that were left bare during initial flap preparation.
b Large sling sutures are placed and tied on the palatal aspects. These sutures should not be over-tightened to allow proper diffusion of nutrients into the transplant.

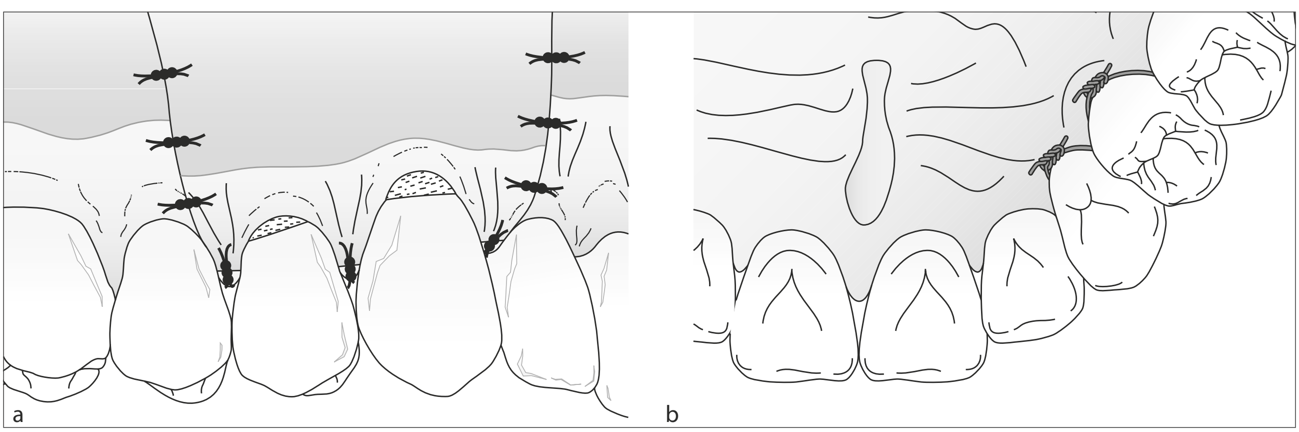
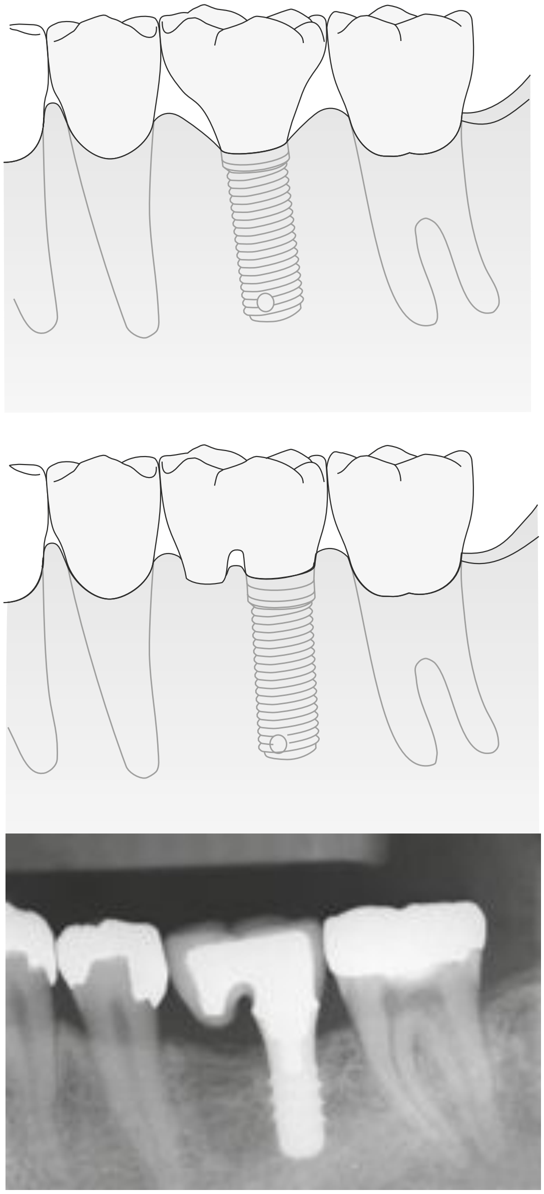


Fig. 8-57a,b Suture the flap
a To adequately cover the transplant, the flap is sutured coronal to its original location.
b Palatal aspect and view of the sutures stabilizing the transplant.

Step #8 Suture the flap Last the flap is sutured as shown in Figure 8-57, that is, coronal to its original position (note the differences in height of the mucogingival line). For suturing, the flap will be stretched somewhat but not "overstretched". This requires that it be well mobilized at its base so that it can be moved around freely and no major backward pull is perceivable. Use interrupted knots and 3-0 or 4-0 suture material.

8.7.4 Class II recessions

The treatment of class II recessions requires double pedicle flaps (Fig. 8-58a). These flaps are actually a more advanced variant of the technique demonstrated above (steps #1 to #8). The essential differences are as follows. First the tissue is incised along the lines shown in Figure 8-58a in which we are actually preparing two flaps: the distal flap (centered on the premolar recession) and the mesial flap. The incision around the canine recession



a

b

Fig. 13-33a,b First molar edentulous space The implant should be placed either mesially or distally to allow the design of a crown as in (**b**) rather than a flaring restoration as in (**a**).

The basic steps of the impression procedure are:

1. Secure the transfer coping to the implant head.
2. Take an impression using an elastomeric material.
3. Release the coping from the implant head and remove the tray.
4. Turn the tray upside down and fasten an implant analog to the "underside" of the transfer coping.
5. Pour the impression and fabricate a working model.

Hence two of the most tedious aspects of impression taking of natural teeth are eliminated. First, there is no need for exposing the margin by gingival deflection and, second, the risk of moisture contamination during the procedure is minimal.

Before starting, the clinician needs to determine whether an open or a closed tray technique will be used.

13.12.1 Open tray technique

The *open tray* technique is the traditional method of securing impression copings to the implant head. In this approach, the copings are screw-fastened to the implant heads, which, in turn, requires that the copings be unfastened before the impression is removed from the mouth (as in Fig. 13-21). Removal is made possible by using a tray provided with openings located on top of the screw heads, thereby providing access for screw release and tray removal (hence the name 'open tray technique').

Procedure The procedural steps are illustrated in Figure 13-34. Figure 13-34a shows the screw-fastening of two transfer copings on the implant heads. Note how the transfer copings fit onto the implant heads in a male-female keying relationship. On Figure 13-34b the operator checks that the opening in the tray allows appropriate access to the screw heads. Then the opening is closed with a sheet of wax, the tray is filled with impression material and seated onto the arch (Fig. 13-34c). After the impression material has set, the wax sheet is removed and the transfer copings are unscrewed from the implant heads (Fig. 13-34d).

13.12.2 Closed tray technique

The open tray technique is somewhat tedious in that the impression tray must be specially prepared. Therefore most manufacturers have designed copings that will securely snap onto the implant heads without the need for additional screw-fastening. Since no perforation of the tray is necessary, this method has been termed 'closed tray technique'. Both techniques are similar in their duplicating accuracy.[73]

Procedure The closed tray technique is illustrated in Figure 13-35. First a snap-on element that reversibly braces around the implant collar is clipped onto the implant head and then an antirotational element (i.e., the positioning cylinder) is inserted into the octagonal key of the connector. The combined action of both elements firmly positions the implant analog during subsequent pouring of the impression.

Independent of the type of connector, accurately positioning the transfer coping onto the implant head is a

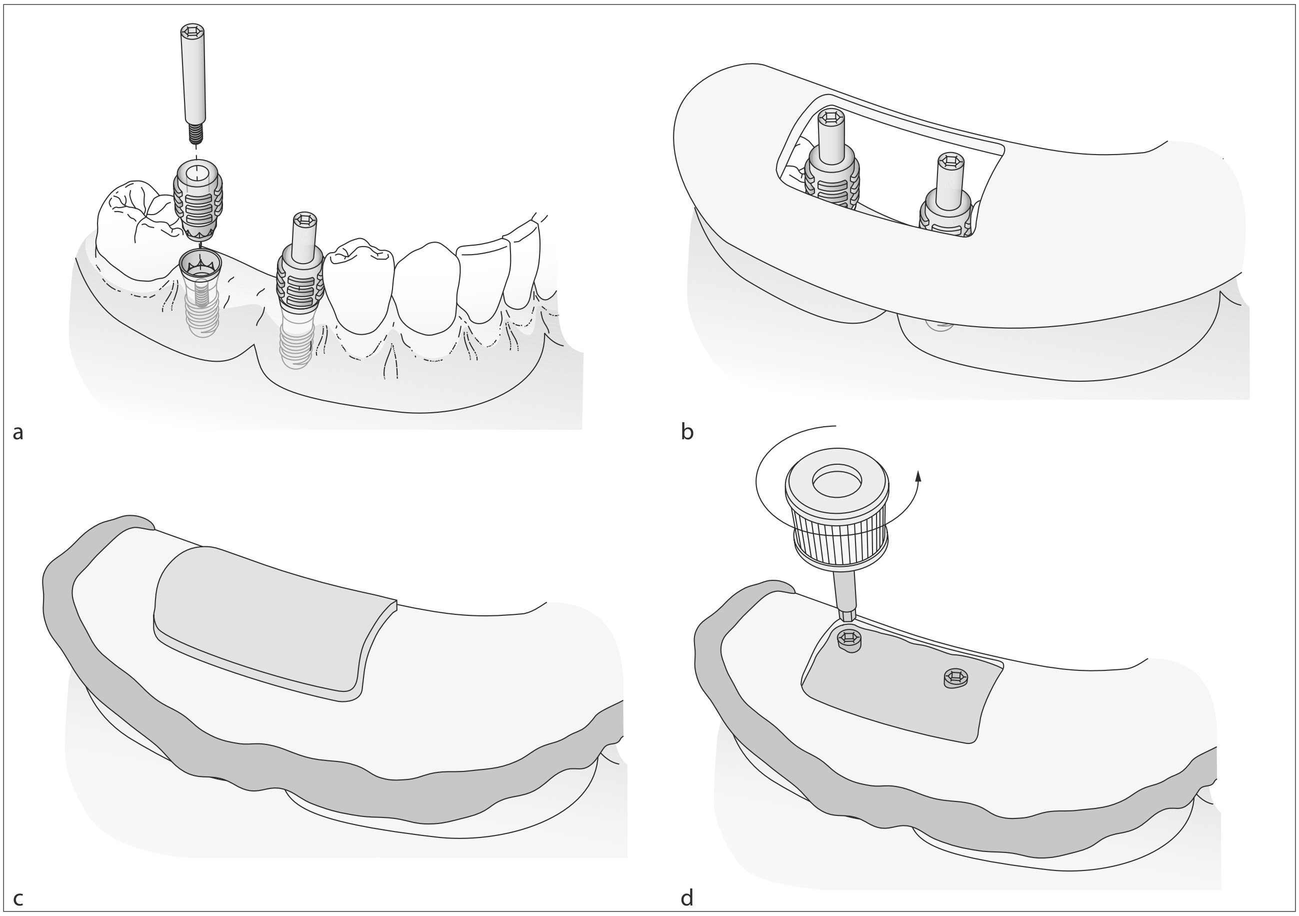


Fig. 13-34a–d Open tray technique
a The transfer copings are screw-fastened into position.
b The tray's opening provides access to the coping screws.
c The opening is sealed with a wax plate and the impression is taken.
d The transfer copings are unscrewed from the implant heads and the impression is removed.

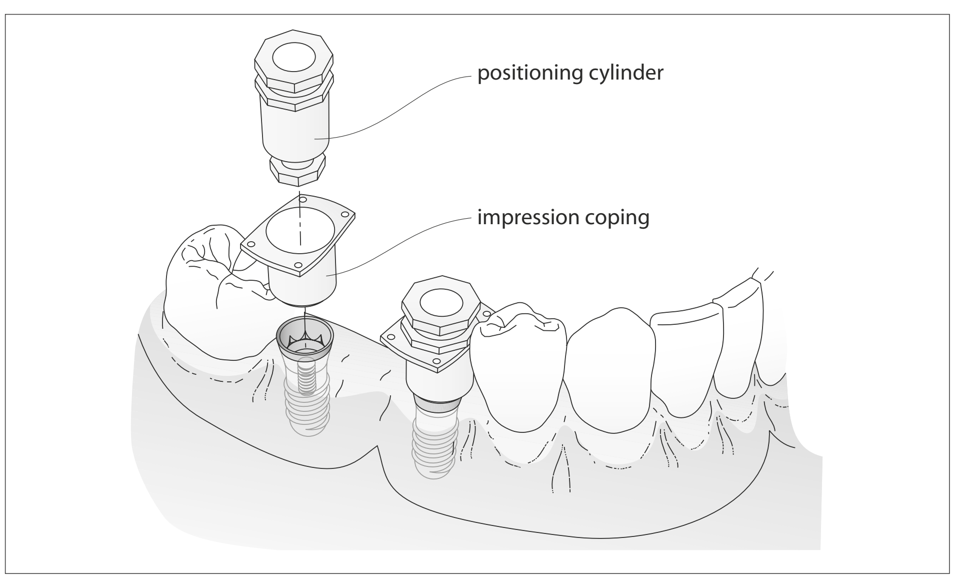


Fig. 13-35 Closed tray technique The impression coping is clipped onto the implant head and the positioning cylinder is seated. After the impression material has set, the coping snaps off the implant head during tray removal.

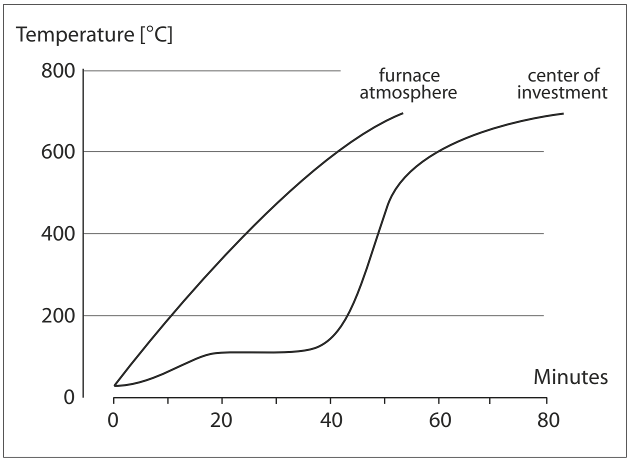


Fig. 18-36 Thermal inertia The investment accumulates energy during heating of the oven (i.e., heat soaking), hence the delay in temperature increase in the center of the investment. Data from Jelenko Corp.

16 to 19 g/cm^3 range for high gold and in the 10 to 15 g/cm^3 range for low gold alloys (the specific value must be provided by the manufacturer). As a rule we will use 50% of the required amount as new and 50% as recycled alloy from previous castings.

We are now ready to proceed with alloy melting and casting. The various heating methods have been discussed previously. The casting machines may be subdivided into two groups: centrifugal and air-pressure driven devices.

Centrifugal casting As the name implies, these machines will drive the molten alloy into the mold using centrifugal force.[115] Thus they feature a rotating beam that spins around a vertical axle with the crucible affixed to one end. They are built so that they start spinning briskly thereby applying a high force during the initial turns. Rotation is generated by a coil which is rewound prior to the procedure and released at the time of casting. The beam itself has a clever design in that it is made of two articulating parts (technical term: *broken arm*). If blowtorch heating is used, this allows the operator to position the crucible in line with the flame, thereby facilitating the melting of the alloy. The design and working principle of a centrifugal casting machine are shown in Figure 18-37.

Whenever a dental alloy is brought to melting temperature in ambient air, a pellicle of oxides will form at the surface. Fortunately these oxides are light in comparison to the weight of the metal. Therefore the centrifugal force (which is proportional to the mass) is fairly inactive on these elements and they therefore tend to stay in the crucible. Nevertheless, these oxides can be eliminated while they are forming by sprinkling an oxide-absorbing chemical on the surface of the melt. Such a chemical is called *flux*. A most widely used flux for gold based alloys is sodium tetraborate ($Na_2B_4O_7$ $10H_2O$), also known as *borax*. Note, however, that there is no universal flux and that other classes of alloys may need appropriately formulated oxide scavengers.

Air-pressure casting In the present context, 'air pressure' may mean positive or negative (i.e., vacuum) pressure or a combination of both. Typically such machines consist of an upper and a lower chamber. The upper chamber is the melting chamber, which houses the cru-

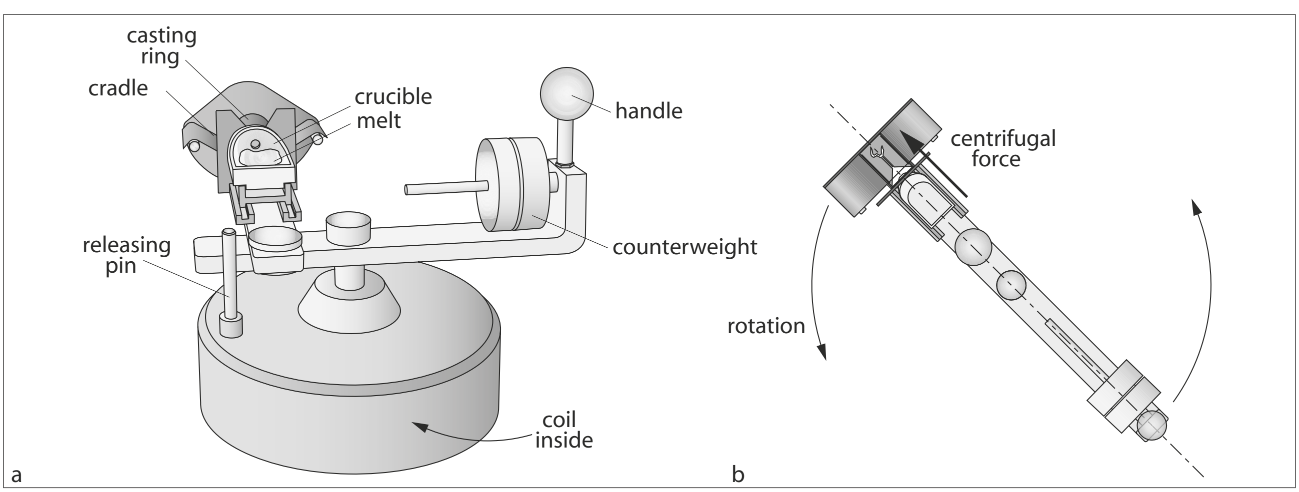


Fig. 18-37a,b Broken arm casting machine
a Machine ready for casting with its spring rewound.
b Top view of same after the releasing pin has been dropped and the broken arm has straightened. The rotational movement generates the centrifugal force that drives the melt into the casting ring.

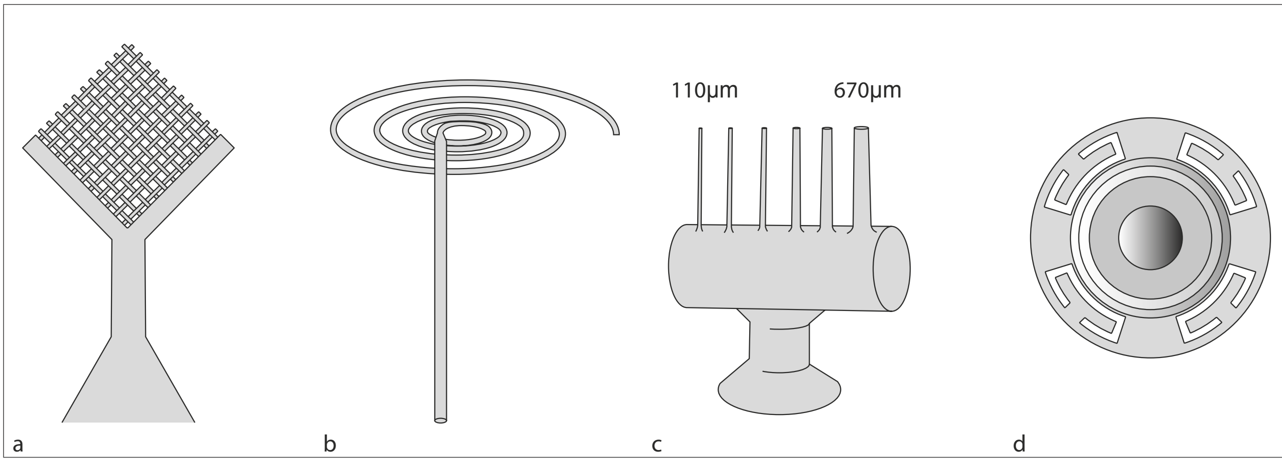


Fig. 18-38 Castability test patterns
a Grid pattern.[119,120] **b** Spiral.[121] **c** Multifiber pattern.[122,123] **d** MBS design.[124–126]

cible, while the lower chamber is the casting chamber in which the investment mold is located. Both chambers are connected via a small channel featuring an obturator. For casting, the metal is placed into the crucible and both chambers are closed airtight. Under computer control, the metal is heated and brought to melting temperature. At this time, air is forced into the upper chamber and the obturator is opened. Simultaneously the melt is sucked into the lower chamber and fills the mold. After the chambers have been depressurized, they may be opened and the mold removed.

The advantage of these techniques lies in the possibility of using inert gasses such as helium or argon during the casting process. These gasses protect molten alloys, first and foremost titanium, from oxidation.

Step #4 Final procedures

Having cast the metal, the mold is removed from the apparatus and immersed in water. This process is called *quenching*. Due to the sudden change in temperature and rapid steam generation, the investment breaks away from the casting. Ideally the casting should now present itself as shown in Figure 18-39.

When present, the dark surface of the casting is removed by *pickling*, that is, heating the discolored casting in acid solution until the oxide layer disappears. The pickling solution typically comprises chemicals of low pH such as sulfuric, hydrochloric, and nitric acids and is removed by flushing in a tap water. The restoration is separated from the sprue with a separating disk.

Box 18-1 Assessing the castability of a metal

Whenever a manufacturer develops a new dental alloy, one important aspect is the metal's castability. To assess casting behavior, the metal is typically flowed into a mold whose intricate geometries and thin channels impede the progression of the molten alloy. By inspecting the resulting cast, the researcher may then rank the newly developed product relative to existing formulations. Ranking will be conducted in terms of progression (i.e., "how far has the alloy progressed inside the mold?") and in terms of porosity (i.e., "what is the casting's density in the thinner potions of the pattern?"). One early technique consisted in casting blade-type (i.e., thinning) patterns.[116–118] Other, more sophisticated geometries proposed to quantify castability are shown in Figure 18-38.

Fig. 18-39 Casting upon devesting Note the smooth, matte surface of the casting and its reproduction in the investment. Picture courtesy of PxDental Corp.

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