Olcay Şakar
Editor

Removable Partial Dentures

A Practitioners' Manual

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Foreword

Removable partial dentures (RPDs) have for long been a very common treatment option for subjects with partial edentulism, i.e., loss of some but not all teeth. Even if the prevalence varies considerably between countries, RPD treatment is in a global context still the most common prosthodontic option for partially edentulous patients. With the successful development of dental implants, many clinicians have come to believe that implant treatment can solve all problems related to tooth loss and substitute both RPDs and complete dentures. This is of course not true, not only because of often-unfavorable oral conditions but also of a number of nondental factors such as fear of surgery and suspicion of implant treatment. The most important obstacle is however economical. A majority of partially edentulous people belong to the poorest section of the population and can never be candidates for any implant treatment. For those, RPDs may be a realistic option. For others with positive experience of an RPD, it will remain an acceptable treatment.

During the last few decades, many dentists have considered RPDs an inferior treatment in the restoration of tooth loss when compared with fixed dental prostheses on natural teeth or on dental implants. It is true that the use of RPDs may involve a risk of potential harm to the oral tissues, probably greater than when using fixed restorations. However, this can be counteracted with proper planning and conduct of the treatment including individual instruction in oral hygiene, pre-prosthetic periodontal treatment, and maintenance of dental and periodontal health after the delivery of the RPD. A satisfactory prognosis for most RPD treatments can be obtained provided correct indications have been used, the dentist and the dental technician collaborate closely in the construction of the prosthesis, and the patient succeeds in maintaining good oral hygiene in the long run. These conditions and the fact that an RPD treatment is more rapidly performed and is less costly than other alternatives indicate that RPDs will remain a viable option in the rehabilitation of partially edentulous patients in the predictable future.

This impressive new textbook combines a straightforward description of well-established principles and methods for the treatment of partially edentulous patients with new and modern knowledge based on available scientific evidence. It contains basic information on the epidemiology of partial edentulism and its effect on the stomatognathic system as well as a detailed account and directions for the clinical and laboratory work in the fabrication of RPDs. There are interesting chapters on advanced RPD techniques using various attachments, double crown systems, and dental implants as well as a discussion on the role of partial edentulism and temporomandibular disorders.

The text is easy to read and supplemented with informative illustrations. The book will therefore be valuable both in undergraduate and postgraduate education. It deserves also to have a place in the office of any dentist treating adult and elderly patients.

Mölndal, Sweden

Gunnar E. Carlsson
LDS, Odont Dr/PhD, Dr Odont hc,
Dr Dent hc, FDSRCS

Preface and Acknowledgments

Istanbul University Faculty of Dentistry, which is located in the most crowded and socioeconomically cosmopolitan city of Turkey, has a remarkable capacity regarding both the number of patients and students. Every year an average of 1800 complete and 1200 removable partial dentures are delivered in the department of prosthodontics.

As an academician, concentrated on removable dentures, my opinion is that with incomplete knowledge of removable dentures any prosthodontic treatment including intraoral appliances would fail to succeed.

Removable partial dentures appeal as complex structures mostly due to the components of the framework to both dental students and dentists. This is the main reason why a great part of the design process is left to dental technicians to be carried out. However, these dentures are simple and cost-effective solutions providing long-term service to a vast majority of patients when they are properly designed.

This book is designed as a guide to simplify basic knowledge and clinical procedures that are often regarded as complicated. It is therefore enriched with visual items like photographs, videos and descriptive illustrations of selected cases, and clinical and desktop procedures as much as possible.

Even though this book is mainly meant for dentists, I hope it will also be an up-to-date handbook for both dental students and technicians.

Prosthodontic treatment may be considered to require the highest levels of artistic care combined with a wide curriculum of knowledge among all disciplines of dentistry. Therefore, I am thankful to my colleagues who contributed to the mutual effort of bringing this book to life with their valuable expertise and knowledge. I am also grateful to my senior tutors, especially to my mentor, Professor Mehmet S. Beyli, who showed me the way through my academic life, and to Professor Gunnar E. Carlsson, who led and inspired me with his knowledge and experience and honored me by writing the foreword.

I am also grateful to Springer for offering me the opportunity to publish this book and for their constant support.

I also thank our Ph.D. students Zeynep Mumcu, Ercan Yılmaz, Fatih Ayçiçek, Anıl Gürel, Pınar Şeşen, and Mehmet Berk Kaffaf who worked hard in every step of the book; Başak Çetinkaya on behalf of Profcat Interactive Media for preparing the illustrations; graphic designer Hakin Des for managing visual items; and our dental technicians Erbil Sümbüllü and Cihan Bozpınar for their valuable input.

I am much indebted to my family, especially to my daughter Doğa, my husband Semir, to my friends and to the families of all authors for their kind understanding and support.

“Knowledge grows when shared,” so I am pretty sure that this book will mature with the precious feedback from our readers and new information will spring out for future generations. Therefore, I would like to thank all readers who share our knowledge in advance.

Istanbul, Turkey Olcay Şakar

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Part I

Introduction to Removable Partial Dentures

1 Current Status on Partial Edentulism and Removable Partial Dentures

Olcay Şakar

Oral health, without a doubt, plays a vital part in both general health and quality of life. In 2010, it was reported that nearly 3.9 billion people have varying levels of oral disease. Among the reviewed 291 diseases and injuries, the leading problem was found to be the caries of permanent dentition. Severe periodontitis ranked 6th, caries of primary dentition came up 10th, and severe tooth loss, referring to less than 9 remaining permanent teeth, 36th. The term "disability-adjusted life years" refers to the sum of lost potential years due to early death and productive years accompanied with disabilities. Severe tooth loss comes out as the main cause of disability-adjusted life years for people over the age of 60. Therefore, tooth loss will continue to be, as it always has been, a major factor affecting individuals' oral and systemic conditions along with their quality of life.
According to the World Health Organization's (WHO) 2012 report, 60–90 % of school children and almost 100 % of the adult population have caries. The ratio of severe periodontitis in middle-aged people between 35 and 44 is 15–20 %. Almost three out of every ten people all over the world between the ages of 65 and 74 are totally edentulous. Furthermore, almost 60 % of tooth loss was found to be due to dental caries that are left untreated, followed by periodontal involvement that led to extraction by 30 %.

As the average life span of the global population is increasing rapidly, the oral health of elderly people is becoming more important.

This elderly population, particularly of more developed countries, is expected to have an annual increase of 1.0 % until 2050 and 0.11 % between 2050 and 2100, which indicates an increase of 45 % by the middle of the century. The number of elderly people, which is currently 287 million people, will increase to 417 million from 2013 to 2050, and by 2100, the elderly population over the age of 60 will be 440 million. The underdeveloped parts of the world show even more vivid dynamic. The 3.7 % yearly rise from 2010 to 2015, which is the highest rate of all times, is expected to be followed by a 2.9 % rise until 2050 and 0.9 % in the next 50 years. 554 million in 2013 will rise to 1.6 billion by 2050 and to 2.5 billion by the end of the century.

The average life span worldwide, which was 69 years between 2005 and 2010, is expected to rise to 76 years from 2045 to 2050 and to 82 years by the end of the century. The scenario is much faster in developed countries. The expected increase for corresponding time intervals is 77–83 years until the middle of the century and to 89 years by 2095–2100.

The rate of total and partial edentulous people in a population and relevant types of prosthetic

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restorations vary from one country to another. However, these parameters change even in a constant population over time. Socioeconomic status, smoking habits, attitude to dental care, and dental anxiety may be mentioned among many possible causes of these variations in both domestic and international populations.

Total edentulism is in global decline, and WHO declared a number of at least 20 teeth to be functional dentition, but it is a pity that even in Europe, where the rate of edentulism is known to be the least, this goal of functional dentition has not yet been achieved for many dentate subjects over the age of 60 (Table 1.1).

The evident increasing elderly population versus decreasing total edentulism tendency indicates that we will be dealing with an escalating number of partial edentulism in the following years. It is not hard to guess that this population will seek less complicated and more affordable treatment options when compared to young people who have higher incomes and motivation to cope with the exhausting, time-consuming, and expensive treatment alternatives.

It should not be ignored that even if a removable partial denture (RPD) is accepted as an economic treatment option for some parts of the world, the simplest basic applications of dentistry are still unaffordable for other less wealthy regions, because poverty is still the major issue which should urgently be addressed. The world is said to be enjoying its most wealthy period since the middle of the twentieth century; however, almost 2.5 billion people live with an income of less than 2 USD per day, which is declared as the poverty line by the World Bank. Furthermore, 1.2 billion people live under 1 USD and that is the hunger line.

Another issue regarding the attainability of health-care services is the ratio of elderly people who need, by various means, the care of the younger generation; this is called "the old age dependency ratio." The increase in this ratio indicates fewer working people taking care of more elderly dependent persons, which in turn complicates the availability of health-care services socioeconomically (Table 1.2).

The type of treatment for partially edentulous patients varies according to local factors like the condition of remaining hard and soft tissues, systemic condition of the patient, socioeconomic status, and patient preferences.

Implant-assisted prostheses for totally and partially edentulous patients have been a choice of treatment for a while. The growing popularity of dental implants also attracted the attention of scientific research, which led them to become a major subject of scientific meetings and events. Being fed by the media with the current innovations in dentistry and dental implants led people to demand these treatment alternatives from their dentists. However, despite this focus on implant dentistry, it is estimated that the number of totally or partially edentulous patients who could receive a treatment involving dental implants covers merely 1.7 % of the relevant population globally. The common cause for this limited availability is the high expense of implants. The idea of com-

Table 1.1 In various countries, the percentages of total edentulism and the people with functional dentition in subjects 60 years old and over

Author (First name)	Publication Date	Country	Sample (*n*)	Age (years)	Prevalence of total edentulism (%)	People with functional dentition (%)
Peltola	2004	Finland	260	≥ 60	42	18 ** #
Petersen	2004	Denmark	1612	65–74	27	40 *
Tramini	2007	France	321	≥ 65	26.9	33.6 *
Madlena	2008	Hungary	612	65–74	19.8	22.6 **
Ribeiro	2011	Brazil	5349	65–74	54.7	10 *
Doğan	2012	Turkey	1545	65–74	48	12.4 **
Urzua	2012	Chile	465	65–74	11.4	23.87 **

**Min* 20 teeth, ** *Min* 21 teeth, #: This data was obtained only from the dentate subjects (n: 151).

Table 1.2 The old age dependency ratio is the ratio of the population aged 65 years or over to the population aged 15–64

Year	World	Sub-Saharan Africa	Africa	Asia	Europe	Latin America and the Caribbean	Northern America	Oceania
2000	11.0	5.6	6.1	9.1	21.8	9.1	18.6	15.3
2005	11.3	5.7	6.1	9.6	23.3	9.7	18.4	15.7
2010	11.7	5.8	6.2	10.1	23.9	10.4	19.6	16.4
2015	12.5	5.8	6.3	11.0	25.9	11.5	22.4	18.4
2020	14.2	5.8	6.5	12.9	29.0	13.3	25.9	20.4
2030	17.8	6.0	7.0	17.1	35.9	18.1	33.5	24.5
2050	24.7	8.0	9.5	27.0	46.6	30.5	36.2	29.0

They are presented as number of dependents per 100 people of working age (15–64)

bining all mandibular complete dentures with two implants has gained wide acceptance, but even this may be limited to the wealthiest countries, which leaves most edentulous patients out of range. As the global dynamics of economics are not likely to change soon, treatment options involving implants will continue to be restricted to a wealthy minority for a long time. On the other hand, a clinical study revealed that even when cost is ignored as a drawback, more than one-third of patients refused to have implants even free of charge to improve the comfort of their mandibular dentures. The main reason for refusal was the patients' concerns regarding surgery. These concerns included the thought of implants as unnecessary, drawbacks related to complications, negative feedbacks from unsatisfied people, and not having enough time for the length of overall treatment.

Recently the term "appropriatech," which is derived from the words "appropriate" and "technology," has been coined to describe a philosophy of treatment approach combining cheap yet effective materials and techniques to make the most cost-effective dentures without ignoring any basic principles of care. And it has been emphasized that innovations in materials and techniques add many advantages to dental practice but may sometimes cause dentists to forget their humanistic priorities.

As a conclusion, the RPD treatment comes out as a less complicated and cost-effective alternative to achieve functional and esthetic goals of prosthetic rehabilitation. Therefore, people who do not want their teeth to be prepared, systemic conditions that jeopardize surgery, and extensive treatment periods may indicate an RPD treatment. In addition, whenever teeth bound large edentulous spaces are present and flange support is inevitable due to extensively reduced alveolar ridge, an RPD is certainly the choice of treatment. Another indication is the maxillofacial defect patient, in whom an RPD can offer the fastest and satisfactory solution. When proper artificial teeth positions are hard to establish or implant positions turn the supra-structure design into a biomechanical challenge, an RPD can be the solution. Similarly, patients who need the reestablishment of occlusal vertical dimension and maximal intercuspal position are also candidates for both provisional and permanent overlay RPDs.

Despite the lack of adequate information about the percentage of patients using RPDs all over the world, limited recent studies from different countries, such as Kazakhstan 54.6 %, European countries 10–19 %, and Taiwan 15.4 %, have revealed that the RPD is still a common treatment alternative and emphasized its indispensable status.

RPDs have been proven to have satisfactory service time free from damaging influences over the remaining tissues if they are properly constructed and maintained. Recently, 90–96.4 % of properly designed RPDs have been found to be still in function after 5 years, 89.8 % after 10 years, and 50.4 % after 25 years.

Despite all these evidence-based advantages of RPDs, probably because of industrial pressure and the commercial bombing of implant manufacturers, they are now pronounced as old fashioned, even among dental practitioners. Actually, the past 50 years introduced interesting novelties to RPDs like the shortened dental arch concept, nonmetal clasp dentures, implant-assisted RPDs, and the digital manufacturing of prosthesis. However, despite the fact that both conventional RPDs and RPDs equipped with these innovations can deliver premium service to patients, recent evaluation of denture services shows that clinicians not only seem reluctant to update their knowledge on RPDs, but they also neglect their conventional knowledge as well. For example, according to several studies, the U-shaped major connector, which is known to have questionable rigidity and therefore should not randomly be chosen, was found to be the most preferred connector for maxillary frameworks. Some other issues are major connectors being fabricated unnecessarily bulky and about rest seats. A wide variety of improper rest seat preparations among practitioners are frequently seen, furthermore in many cases rest seats are even not prepared. Another finding is the use of flexible thermoplastic major connectors lacking metal framework and rests.

While performing our mission as health-care professionals, we dentists should put great effort into preventive dentistry and avoid overtreatment. The priority of fixed prosthodontics, whenever possible, is surely out of the question, and one day genetic engineering may provide us with the technology to prevent or replace tooth and tissue loss. The indications for fixed prosthodontics are still limited to an appropriate group of patients, and, unfortunately, neither of these options is fully available today nor will they be in the near future. Therefore, despite all scientific and technologic advances, treatment of tooth loss will be continued by fixed prosthesis, occasionally RPDs, or even complete dentures in the upcoming years.

It is up to us to choose the most cost-effective treatment option that will serve the needs of the patient for the longest possible time. RPDs have been and probably are still the most favorable treatment option for most partially edentulous patients; therefore, the routine prosthodontic practice and knowledge should be kept updated and supported by the developments in the field. It should strongly be kept in mind that our capabilities are limited to our knowledge; we can only deliver what we know.

It was in our best interest while writing this book to provide a harvest of knowledge regarding the current, practical, scientific, and affordable ways to construct proper removable partial dentures. We hope to explore more scientific-based attention to RPDs in the near future, which will possibly make them a good and an easy choice of treatment.

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2 The Effects of Partial Edentulism on the Stomatognathic System and General Health

Olcay Şakar

2.1 Definitions

Combination syndrome The characteristic features that occur when an edentulous maxilla is opposed by natural mandibular anterior teeth, including loss of bone from the anterior portion of the maxillary ridge, overgrowth of the tuberosities, papillary hyperplasia of the hard palate's mucosa, extrusion of the lower anterior teeth, and loss of alveolar bone and ridge height beneath the mandibular removable dental prosthesis bases—also called anterior hyperfunction syndrome

Residual ridge The portion of the residual bone and its soft tissue covering that remains after the removal of teeth

Residual ridge resorption A term used for the diminishing quantity and quality of the residual ridge after teeth are removed

Supraeruption Movement of a tooth or teeth above the normal occlusal plane

Tooth loss is a very important phenomenon which affects both oral and systemic health. Dentists should be aware of the possible consequences or concomitant conditions of tooth loss and inform their patient or refer them to a physician when necessary. It is also vital to know which dentition and/or patient is at a greater risk due to tooth loss and to decide the treatment plan in the light of these facts.

Dentition is completed by the eruption of the second molars. Thus occlusion is achieved by the existence of 28 teeth. The absence of one or more third molars has been observed in approximately 25 % of the population.

For the most part, posterior tooth loss is observed more than anterior tooth loss and upper teeth are lost before lower teeth. Initially, the first molars are commonly lost. Afterwards, second molars, second premolars, and first premolars may follow. Posterior tooth loss generally occurs bilaterally.

Tooth loss may impair the functional stability of the stomatognathic system. The aftereffects of tooth loss show individual differences, which depend on local and systemic factors. Number and location of the missing teeth, occlusal relationships, the periodontal status of the remaining teeth, and movement pattern or size of the tongue can be considered as local factors. Neuromuscular control mechanism, age, psychological status, and general resistance can be accepted as systemic factors. Thus, it has been concluded that it is not possible to predict the identical consequences of tooth loss for every patient, and it should be noted that every partial edentulism does not have to be treated immediately (see Chap. 5).

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2.2 Consequences of Tooth Loss

In spite of the individual differences, one or more following consequences that might affect the oral and systemic health can be observed after tooth loss:

1. Alveolar residual bone loss is the main result of tooth loss (Fig. 2.1a, b) and occurs rapidly in the first 3–6 months after the extraction; however, it continues throughout the life at a slower rate. Various results from studies have shown that horizontal bone loss (average 3.87 mm) was more than vertical bone loss (average 1.67 mm). Both horizontal and vertical bone loss have mainly been observed at the buccal part of the residual ridge which becomes narrower and shorter after the resorption process. Therefore, the alveolar ridge is relocated in a more posterior position. Relocation of the ridge is more noticeable in the maxilla, necessitating more lip and cheek support in the buccal region.

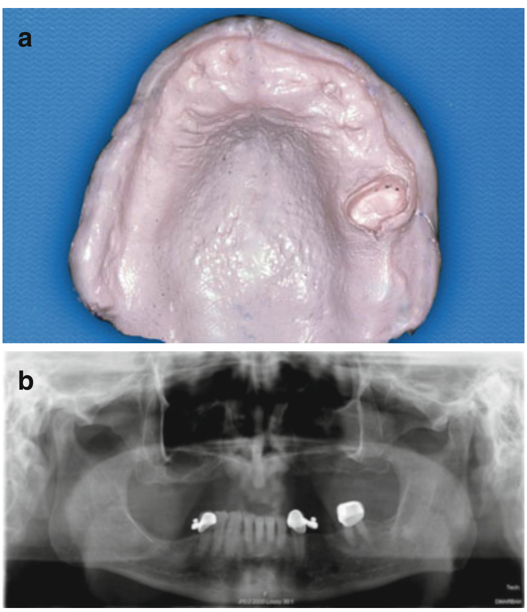

Fig. 2.1 (**a**, **b**) Tooth loss results in alveolar bone loss showing individual differences. Preserving of teeth is vital to protect the residual bone (**a**), and severe bone loss (**b**) can be prevented or slowed down by saving the teeth as long as possible with different prosthodontic treatment alternatives

2. Migration of the teeth in the form of tipping, extrusion, and rotation may occur, especially after the first year of the extraction. It has been demonstrated that supraeruption occurred in most of the unopposed teeth, usually resulting in periodontal attachment reduction, and is mostly observed in the upper arch (Fig. 2.2a, b). Supraeruption can be divided into active eruption (in which the tooth erupts out of its socket while the periodontium remains stable as seen in Fig. 2.2) and growth of the periodontium (growth in an occlusal direction of the periodontal tissues including the alveolar bone, together with the tooth as seen in Fig. 2.3a, b). The teeth adjacent to the extraction site have a tendency to tip towards this side. While rotation of teeth mesial to the edentulous site has been more observed in the mandible, rotation of teeth distal to the edentulous ridge is greater in the maxilla. This shift may continue until the tooth encounters an obstacle (such as other teeth or the residual ridge) and a new occlusal balance may develop. After the migration of the teeth, premature contacts and interferences may occur. Thus, pseudoprognathism and retruded contact position interferences (Fig. 2.4a, b) may develop or a pathway may

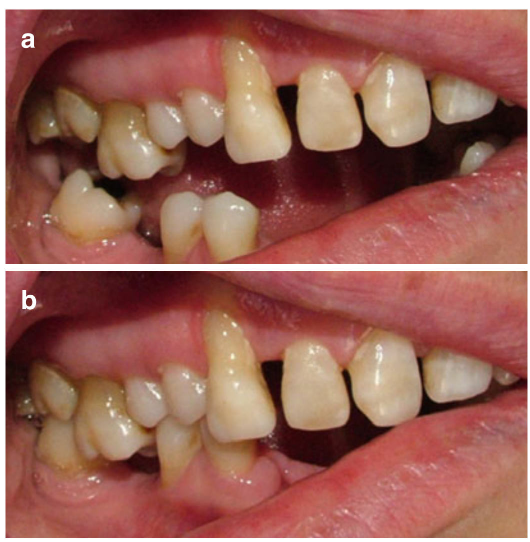

Fig. 2.2 (**a**, **b**) Active eruption in maxillary first molar

be created by wearing between the opposite teeth (Fig. 2.5a–c). Further changes that could affect oral health may develop, such as traumatic occlusion, root and furcation exposure, soft tissue trauma, plaque retention, and loss of proximal contacts resulting in food impaction.

There is no consensus regarding the negative effects of occlusal interferences on the stomatognathic system. Furthermore, it should be noted that the relationship between tooth loss or occlusal factors and temporomandibular disorders is controversial (see Chap. 21).

3. Enlargement of the tuberosities may be observed. When mandibular molars are lost, maxillary teeth may extrude together with the alveolar process, and as a consequence, excessive fibrous connective tissue may occur. If this tissue cannot be reduced surgically in the post-extraction phase, it may result in contact with the retromolar pad, inappropriate occlusal plane, and/or lack of space for denture material (Fig. 2.6a, b). Although it is not observed in all cases, overgrowth of the tuberosities can also be observed in cases which have only anterior mandibular teeth and a maxillary complete denture. Additionally, it has been revealed that these patients are at risk of the formation of hypermobile tissue in the anterior maxillary jaw region (Fig. 2.7a, b). These processes were explained by Kelly as two symptoms of the "combination syndrome."
4. Loss or decrease of occlusal vertical dimension may develop. Alterations of occlusal vertical dimension may occur due to loss of tooth contacts, displacement of the teeth, and uncompensated tooth wear (see Chap. 22).
5. When all posterior occlusal units have been lost, overloading of the anterior tooth region may occur (Fig. 2.8).
6. Masticatory function may be impaired and/or unilateral or anterior chewing may occur, especially in free-end saddle partially edentulous cases. Digestion begins in the mouth, and many nutrients need chewing before swallowing. Patients with impaired dentition may encounter nutritional problems which may lead to systemic disorders and psychosocial

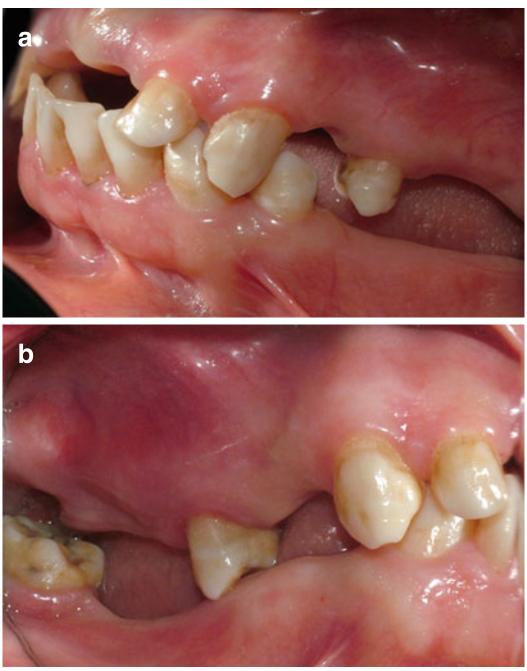

Fig. 2.3 (**a**, **b**) In some cases, supraeruption of the teeth occurs accompanied by the growth of the periodontal tissues and alveolar bone

Fig. 2.4 (**a**, **b**) After tooth loss, migrated teeth may cause premature contacts and interferences

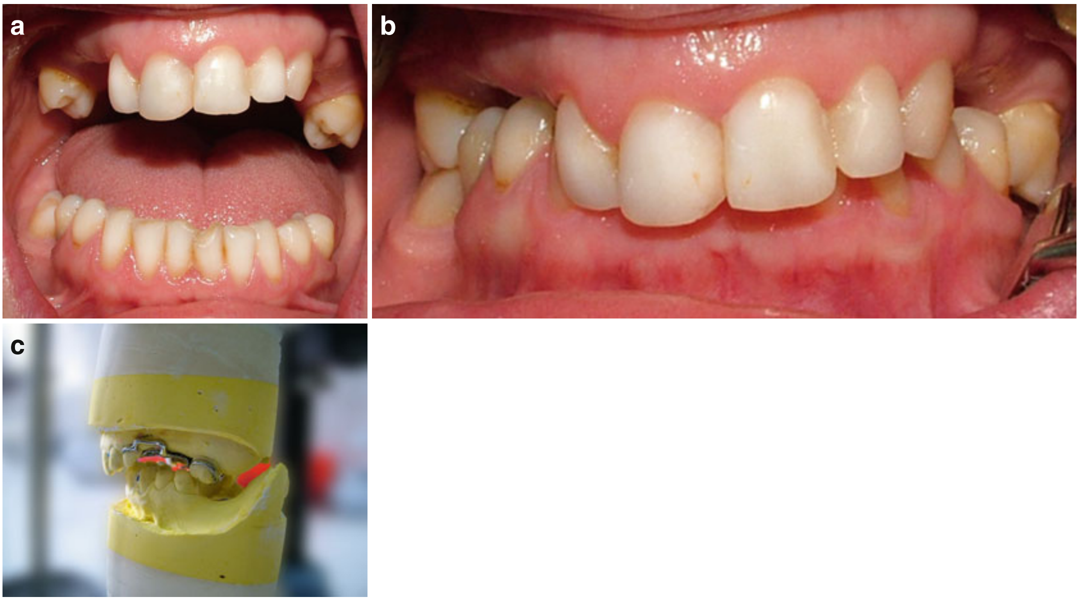

Fig. 2.5 (**a**–**c**) After 11 years of the partial edentulism without any prosthetic treatment, patient is closing her mouth on a pathway formed by wearing on the second premolar

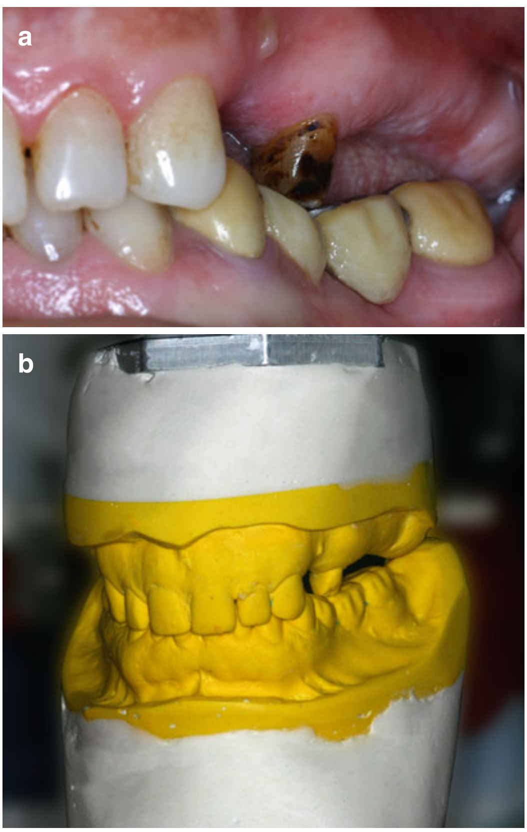

Fig. 2.6 (**a**, **b**) Overgrown tuberosity may contact with the retromolar pad leaving no space for a prosthetic restoration

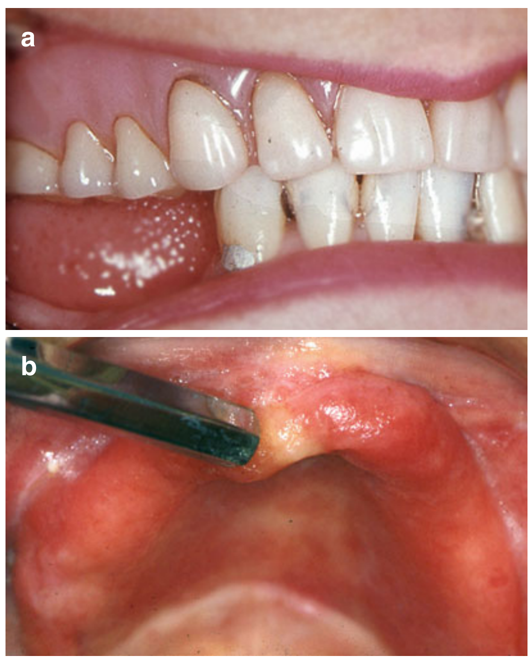

Fig. 2.7 (**a**, **b**) In cases having anterior mandibular teeth and maxillary complete denture, hypermobile tissue in the anterior region of the maxilla may be more likely to develop

Fig. 2.8 Posterior tooth loss may result in overloading of the anterior tooth. This situation may be further exacerbated by the presence of periodontal problems

difficulties. It has been revealed that the chewing ability is significantly impaired when more than 7 teeth are missing and chewing ability is satisfactory with 20 or more teeth, especially if the teeth are well positioned as in the premolar dental arch. As a result, numbers and types of occluding pairs of teeth are important to evaluate masticatory function (shortened dental arch—see Chap. 5). In cases having large or bilaterally tooth-bound edentulous areas, masticatory function may also be disturbed. Although these cases may be able to chew with most of the remaining occlusal contacts, they may need longer chewing time and swallow larger particles, which may lead to digestive problems, and this may cause them to prefer easy-to-chew food items.

7. Especially in the absence of anterior teeth and maxillary premolars, esthetics, speech, and physiognomy are affected (Fig. 2.9a, b). Psychosocial problems (such as loss of self-esteem and self-confidence) and disorders may develop. It has been shown that adults with depression and anxiety were more likely to have tooth loss. In other words, adults with depression, either in the long term or short term, were significantly more likely to have had at least one tooth removed than those without these disorders.

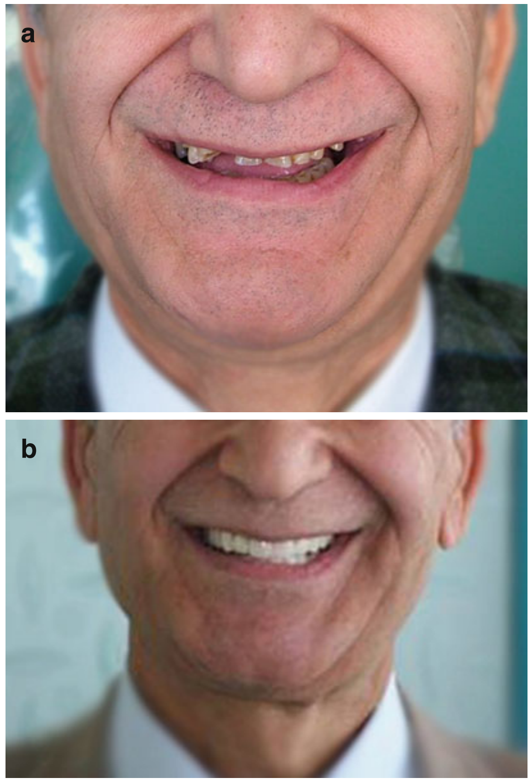

Fig. 2.9 (**a**, **b**) Loss of teeth can also cause psychological problems in addition to functional problems

8. Loss of teeth may cause and/or increase risk of several systemic diseases:
   (a) As patients with impaired dentition tend to eat soft food and avoid vegetables or fruit which are hard, they have a higher risk of obesity. This may result in increased gastrointestinal disorders, high cholesterol levels, cardiovascular diseases, and noninsulin-dependent diabetes mellitus. A recent study also showed that the number of natural teeth is inversely associated to the presence of metabolic syndrome in adults.
   (b) It has been demonstrated that tooth loss increases the risk of electrocardiographic abnormalities, hypertension, heart failure, ischemic heart disease, stroke, and aortic valve sclerosis. It has been revealed that both men and women with 1–10 teeth had a significantly higher risk of coronary heart disease compared to subjects with

25–32 teeth. Furthermore, a similar study has showed that a sevenfold increased risk for mortality from coronary heart disease has been observed in subjects with less than 10 teeth compared to subjects with more than 25 teeth.

(c) It has been shown that tooth loss may increase the proportion of gastrointestinal disorders, such as chronic inflammatory changes of the gastric mucosa, upper gastrointestinal and pancreatic cancer, and peptic or duodenal ulcers.

(d) The results of a study showed a significant positive correlation between tooth loss and orodigestive cancer mortality risk, but a causal relationship has not been determined yet.

(e) It has been shown that periodontal disease may result in tooth loss, and this may increase the risk of chronic kidney disease.

(f) Missing teeth may affect the daily functions, physical activity, and quality of life. It has been shown that the above factors are affected by number, location, and distribution of missing teeth. It has been revealed that the number of occluding pairs is an important factor for oral health quality of life and having less than 20 teeth increases the prevalence of negative impacts. It has also been shown that having nine and fewer teeth had a significant effect on the physical index of general health-related quality of life. Furthermore, it has been found that reduced dentition, if not treated with a removable or fixed denture, reduces the physical index of quality of life to the same level as cancer or renal diseases.

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3 Classification of Partially Edentulous Arches

Olcay Şakar

Classification of partially edentulous arches is vital in order to ensure effective communication between dental professionals and to discuss the most suitable treatment plan for patients. Partially edentulous arches have been classified according to several methods. The Kennedy classification proposed by Dr. E. Kennedy is the most widely accepted and used classification method due to its simplicity and ease of application, with nearly 65,000 possible combinations of partially edentulous arches. Although this system does not give information about the condition of the teeth and periodontal tissues, it allows easy visualization of the arches, differentiation between free-end and tooth-bounded partially edentulous arches, and logical approach to design. Therefore, only Kennedy classification is described in this book. Additionally, a classification system (Implant-Corrected Kennedy/ICK) for partially edentulous arches incorporating implants placed or to be placed for an RPD is described and used. It is proposed by Al-Johany SS. and Andres C. and based, with modifications, on the Kennedy classification system.

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3.1 Kennedy Classification

Partially edentulous arches are divided into four classes:

Class I: Bilateral edentulous areas located posterior to the remaining natural teeth (Fig. 3.1)
Class II: A unilateral edentulous area located posterior to the remaining natural teeth (Fig. 3.2)
Class III: A unilateral edentulous area with natural teeth located both anterior and posterior to it (Fig. 3.3)
Class IV: A single but bilateral (crossing the midline) edentulous area located anterior to the remaining natural teeth (Fig. 3.4)

Fig. 3.1 Kennedy Class I

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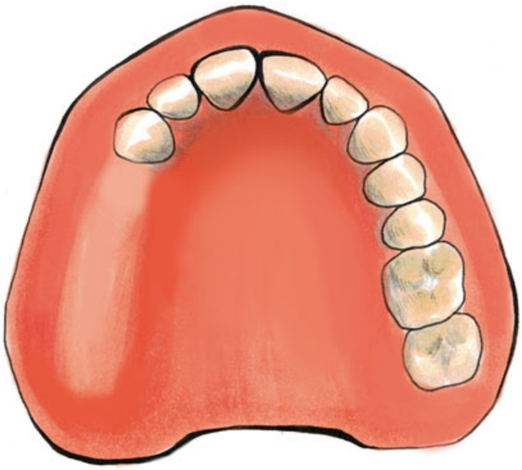

Fig. 3.2 Kennedy Class II

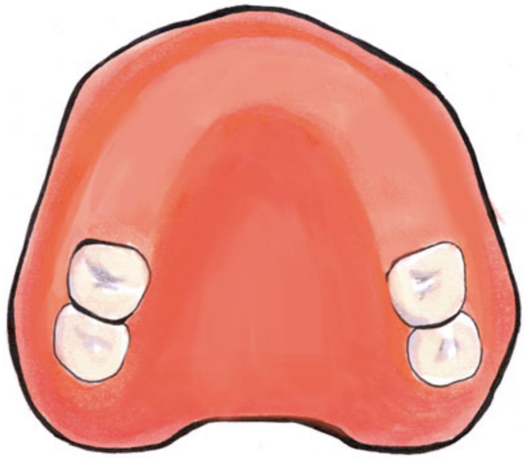

Fig. 3.4 Kennedy Class IV

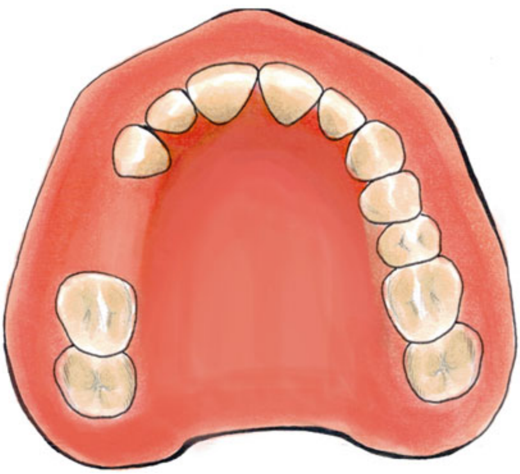

Fig. 3.3 Kennedy Class III, at the same time, this case can be named as Kennedy–Applegate Class VI according to Applegate's modification

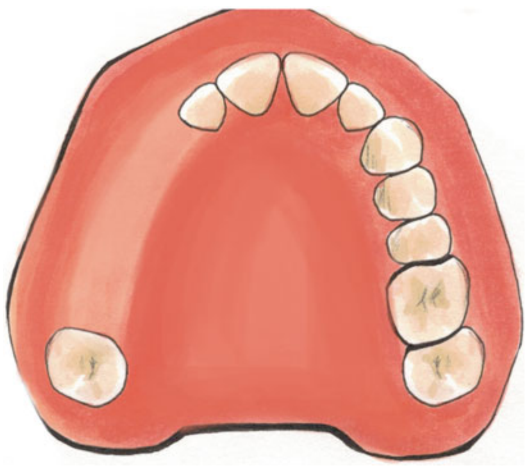

Fig. 3.5 Kennedy–Applegate Class V

3.1.1 Applegate's Modification (Kennedy–Applegate Classification System)

The Kennedy classification has been modified by Applegate with the addition of two more groups.

Class V: Tooth-bounded edentulous area where the anterior abutment is a weak (e.g., lateral incisor) abutment that is incapable of providing support for a conventional RPD and edentulous space is long (Fig. 3.5).

Class VI: Tooth-bounded edentulous area but restoration can be a fixed partial denture, because the edentulous space is short and abutments are capable of providing support for a denture (Fig. 3.3).

3.1.2 Applegate's Rules

Certain rules have been provided by Applegate to govern application of the Kennedy classification.

1. The classification should include only natural teeth involved in the definitive dentures and

should follow rather than precede extraction. (Classification is identified after extraction(s).)

2. If the third and second molars are missing and not to be replaced, they are not considered in the classification. But if they are present and used as an abutment, they are considered in the classification.
3. The main classification is determined by the most posterior area (or areas).
4. Edentulous areas other than those determining classification are called "modification," and the number of modification spaces is considered, not their extent (Figs. 3.6, 3.7, and 3.8).

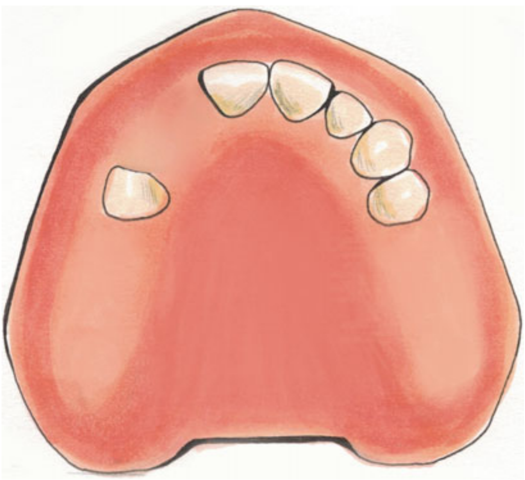

Fig. 3.6 Kennedy Class I, mod. 1

5. Modification spaces can be included in Class I, II, and III. Class IV can have no modification.

3.2 Implant-Corrected Kennedy Classification System

The new classification system was named the Implant-Corrected Kennedy (ICK) Classification System in order to be differentiated from other partially edentulous arch classification systems.

This system is used with the following guidelines:

1. If the edentulous space needs to be restored with an implant-supported fixed partial denture, it is not included in the classification.
2. The maxillary arch is drawn as a half circle facing up and the mandibular arch as a half circle facing down. The orientation of the drawing is "doctor's view," so the left and right sides correspond to the patient's right and left, respectively.
3. The classification begins with the phrase "Implant-Corrected Kennedy (class)," followed by the description of the classification. It is abbreviated as follows:
   (a) ICK I, for Kennedy Class I situations (Fig. 3.9)

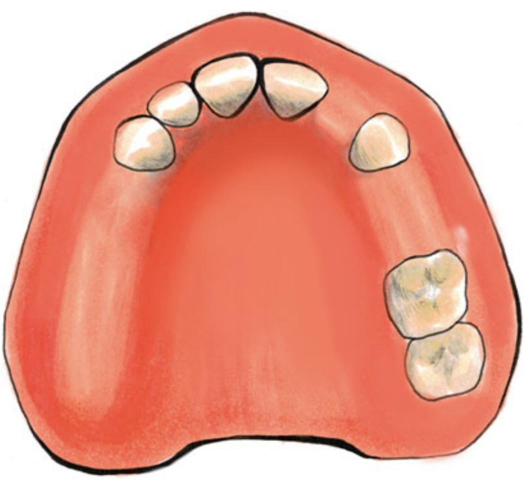

Fig. 3.7 Kennedy Class II, mod. 2

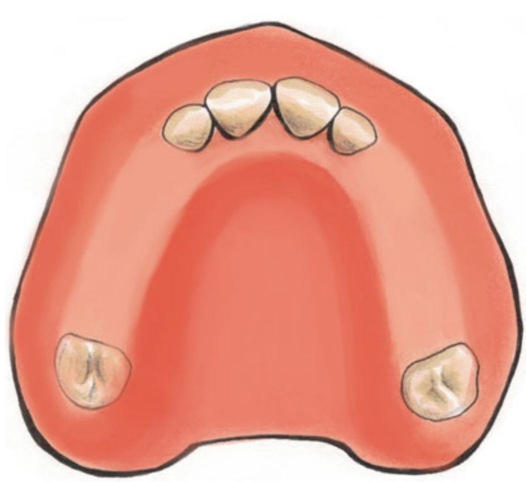

Fig. 3.8 Kennedy Class III, mod. 1

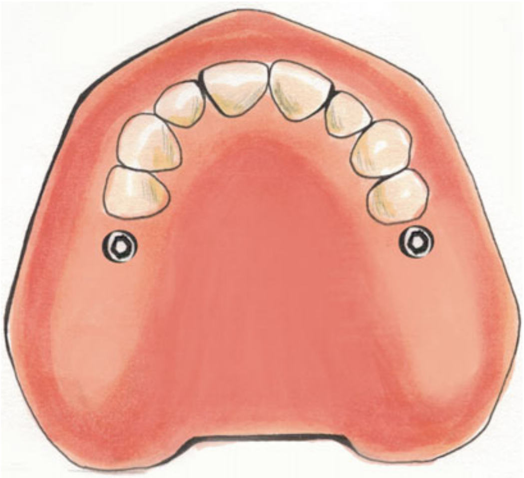

Fig. 3.9 ICK I (#15, 25)

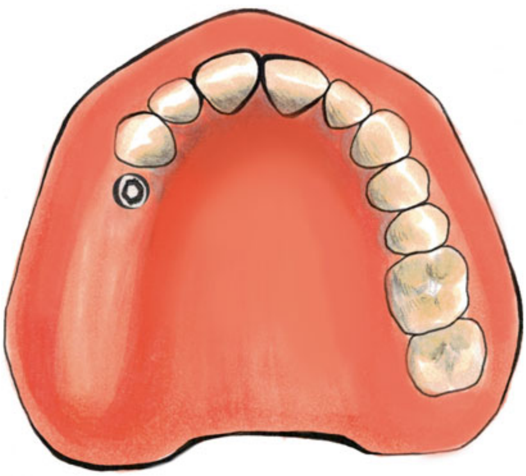

Fig. 3.10 ICK II (#14)

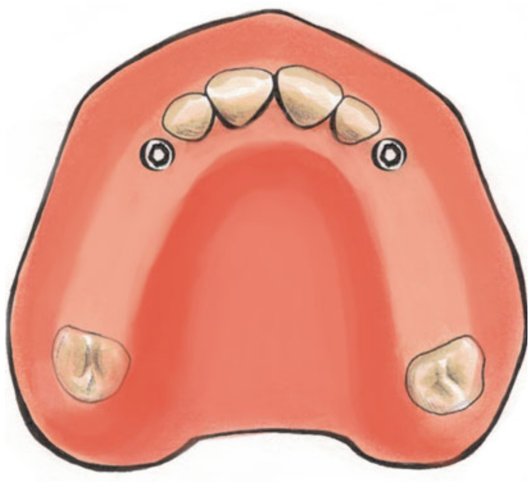

Fig. 3.11 ICK III mod 1 (#13, 23)

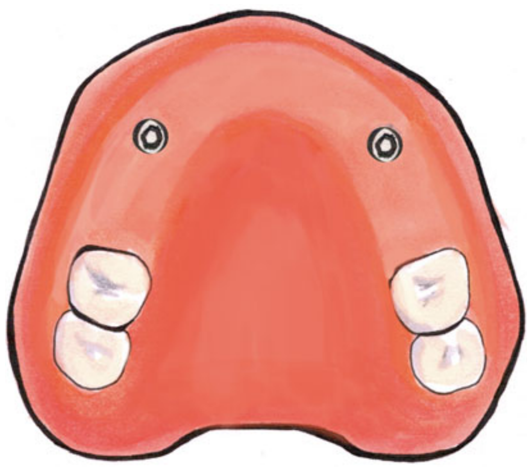

Fig. 3.12 ICK IV (#13, 23)

(b) ICK II, for Kennedy Class II situations (Fig. 3.10)
(c) ICK III, for Kennedy Class III situations (Fig. 3.11)
(d) ICK IV, for Kennedy Class IV situations (Fig. 3.12)

4. The abbreviation "max" for maxillary and "man" for mandibular can precede the classification.
5. The word "modification" is abbreviated as "mod." and follows the abbreviation of "ICK."
6. Roman numerals are used for the classification, and Arabic numerals are used for the number of modification spaces and implants.
7. All tooth numbering systems can be used to give the number and exact position of the implant in the arch. The "Fédération Dentaire Internationale (FDI)" system is used in this book.
8. The classification is presented according to the following order:
   (a) The abbreviation of maxilla or mandible as "max" and "man," respectively, where the drawing is absent
   (b) Main classification

   (c) The number of modification spaces as "mod"
   (d) The number of implants in parentheses according to their position in the arch (according to the FDI numbering system) preceded by the number sign (#) (e.g., ICK I mod. 2 (# 16, 27)
9. The classification can be used both before and after placement of implants to discuss the treatment plan or to indicate the number and position of implants to be placed for implant-assisted RPDs.

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Part II

Treatment Planning, Mouth Preparation and Impression Procedures

4 Biomechanics of Removable Partial Dentures

Canan Bural

4.1 Definitions

Abutment (**1**) That part of a structure that directly receives thrust or pressure, an anchorage. (**2**) A tooth, a portion of a tooth, or that portion of a dental implant that serves to support and/or retain a prosthesis.

Biomechanics (**1**) The application of mechanical laws to living structures, specifically the locomotor systems of the body. (**2**) The study of biology from the functional viewpoint. (**3**) An application of the principles of engineering design as implemented in living organisms.

Denture-supporting structures The tissues (teeth and/or residual ridges) that serve as the foundation for removable partial or complete dentures.

Fulcrum line (**1**) A theoretical line passing through the point around which a lever functions and at right angles to its path of movement. (**2**) An imaginary line, connecting occlusal rests, around which a partial removable dental prosthesis tends to rotate under masticatory forces. The determinants for the fulcrum line are usually the cross-arch occlusal rests located adjacent to the tissue-borne components.

Fulcrum line of a removable dental prosthesis A theoretical line around which a removable dental prosthesis tends to rotate.

Rotation (**1**) The action or process of rotating on or as if on an axis or center. (**2**) The movement of a rigid body in which the parts move in circular paths with their centers on a fixed line called the axis of rotation. The plane of the circle in which the body moves is perpendicular to the axis of rotation.

Stress Force per unit area, a force exerted on one body that presses on, pulls on, pushes against, or tends to invest or compress another body, the deformation caused in a body by such a force, and an internal force that resists an externally applied load or force. It is normally defined in terms of mechanical stress, which is the force divided by the perpendicular cross-sectional area over which the force is applied.

Biomechanics is the study of the structure and function of biological systems by means of mechanics. Functional mandibular movement is defined as all the normal, proper, or characteristic of three-dimensional movements of the mandible during speech, mastication, swallowing, and other associated movements. Most functional movements occur during mastication and speech. A removable partial denture (RPD) is not rigidly

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attached to the teeth, and, therefore, there is a potential for movement of the denture when these functional movements create forces on the teeth and denture. The practitioner should begin with the understanding of how these three-dimensional functional forces (mechanics) act on the biological environment (abutment teeth, residual ridges, and alveolar mucosa). During treatment planning of the RPD, the clinician must consider the biomechanics of the RPD as well as the patient's comfort, esthetics, and prognosis of the abutments to withstand the forces.

4.2 Understanding Biomechanical Aspects

The functional forces acting on the oral cavity are to be considered in terms of direction, duration, frequency, and magnitude. The abutment teeth and the residual alveolar ridges are the supporting structures that are subjected to these functional forces. When considering the biomechanical aspects of treatment planning of the RPD, the clinician should criticize the resistance capacity of the supporting structures against the functional forces.

4.2.1 Rotational Movement

Mastication is not merely a vertically oriented function and occurs in three dimension. Although it seems that the food is chewed vertically, mastication occurs on the sloped cusps or planes; therefore, the resulting forces that cause the RPD to potentially move are the combination of the forces that occur in multiple planes. The magnitude and the loading direction of the multiple vectors and the possible movement of the RPD should be taken into consideration when designing an RPD. It is not possible to completely prevent the movement of the RPD, but it is possible to minimize the possible movement during RPD design planning, so that the remaining teeth and the tissues would be least affected by the functional forces and their vectors.

Movement in the human body can occur in any of the three planes:

1. Sagittal plane
2. Frontal plane
3. Horizontal plane

The potential movement of the RPD may occur in any of these planes, which intersect each other at right angles, and the intersection of any two planes forms a linear axis. These axes are:

1. Horizontal axis
2. Vertical axis
3. Sagittal axis

The RPD rotates around any of the three axes within a plane that is perpendicular to that axis.

4.2.1.1 Rotational Movement in the Sagittal Plane Around the Horizontal Fulcrum Line

A horizontal fulcrum line will extend through the rests on the most distally placed abutment teeth, and the rotational movement will be around the mediolateral axis that will cause the distal extension move away or towards the tissue in the sagittal plane. This fulcrum line is called as the principal fulcrum line. The resultant force on the abutment tooth due to the rotational movement is mesioapically or distoapically directed (Fig. 4.1).

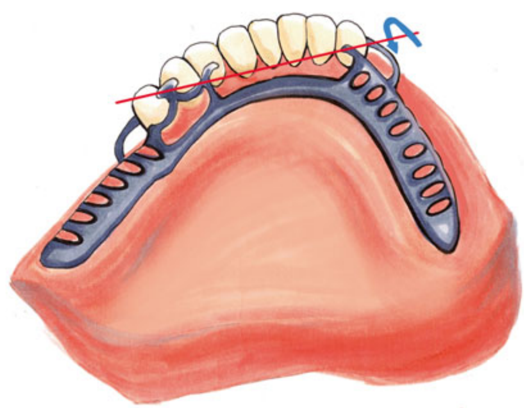

Fig. 4.1 A horizontal fulcrum line will extend through the rests on the most distally placed abutment teeth, and the rotational movement will be around the mediolateral axis that will cause the distal extension to move away or towards the tissue in the sagittal plane. This fulcrum line is called as the principal fulcrum line. The resultant force on the abutment tooth due to the rotational movement is mesioapically or distoapically directed

4.2.1.2 Rotational Movement in the Frontal Plane Around the Anteroposterior Horizontal Fulcrum Line

An anteroposterior horizontal fulcrum line will extend through one of the rest on the most distal abutment tooth to the edentulous ridge on one side of the dental arch. The rotational movement around the anteroposterior rotational axis will cause the denture to dislodge or flip from one side to the other in the frontal plane. In bilaterally distal extension cases, there will be two anteroposterior horizontal fulcrum lines. The resultant force on the abutment tooth due to the rotational movement is mostly horizontally directed (Fig. 4.2).

4.2.1.3 Rotational Movement in the Horizontal Plane Around the Vertical Fulcrum Line

The third fulcrum line is the vertically extending fulcrum line on the midline of the anterior teeth. This rotational movement around the vertical fulcrum line will also cause the denture to move relative to the edentulous alveolar ridge (mediolateral movement) in the horizontal plane (Fig. 4.3).

Although these rotational movements and the resulting displacement of the RPD cannot be completely eliminated, minimum rotation as possible and minimum trauma to the supporting structures of the denture (abutment teeth and residual ridges) can be considered during treatment planning and RPD design solutions in order to avoid off-axially directed forces.

4.2.2 Biomechanical Design Principles

The design of the RPD necessitates the knowledge and the understanding of the working principles of two of the six simple machines, such as the lever, and the inclined plane may be helpful when designing an RPD to function properly under the functional forces.

4.2.2.1 The Inclined Plane

The inclined plane is simply a flat surface raised at an angle, like a ramp. The inclined plane can easily lift a load along the ramp that would be more difficult to lift the same amount of load straight up. The angle of the inclined plane determines the amount of effort that is needed to lift the load. The higher the angle, the more effort is required. The force of movement also exerts a lateral force both on the object and the inclined plane (Fig. 4.4).

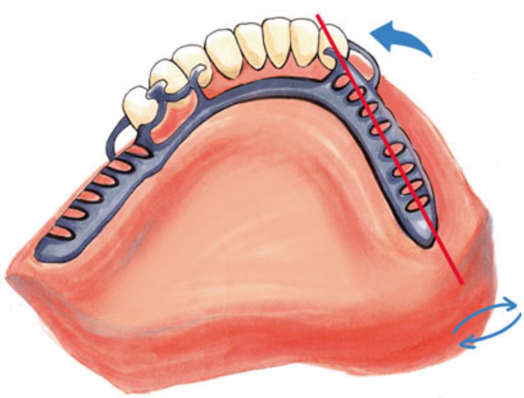

Fig. 4.2 An anteroposterior horizontal fulcrum line will extend through one of the rest on the most distal abutment tooth to the edentulous ridge on one side of the dental arch. The rotational movement around the anteroposterior rotational axis will cause the denture to dislodge or flip from one side to the other in the frontal plane. The resultant force on the abutment tooth due to the rotational movement is mostly horizontally directed

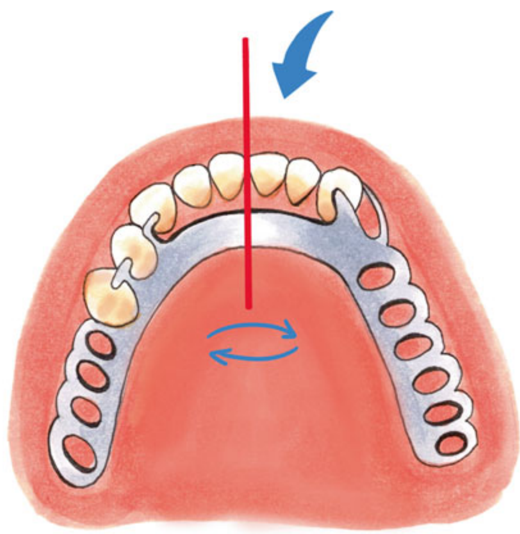

Fig. 4.3 The fulcrum line is the vertically extending fulcrum line on the midline of the anterior teeth. This rotational movement around the vertical fulcrum line will also cause the denture to move relative to the edentulous alveolar ridge (mediolateral movement) in the horizontal plane

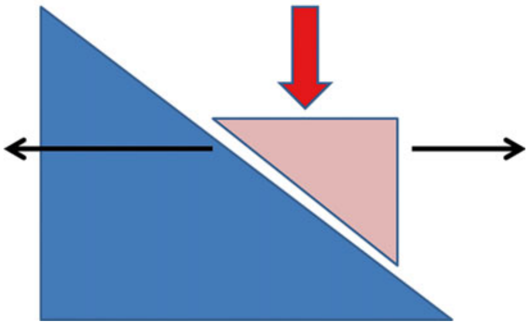

Fig. 4.4 The inclined plane. When an effort (occlusal load) is applied on the object (the occlusal rest), the object is moved along the plane (lingual surface of the abutment teeth). The angle of the inclined plane determines the amount of effort that is needed to lift the load. The higher the angle, the more effort is required. The force of movement also exerts a lateral force both on the object and the inclined plane

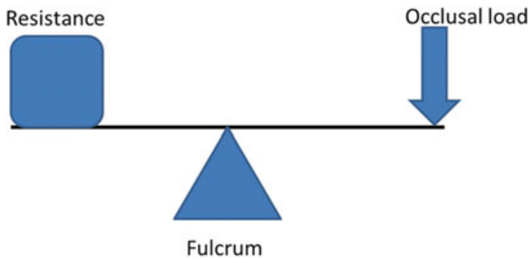

Fig. 4.5 Class I type leverage system. Fulcrum is located in the middle in between the load and the exerted effort

The remaining anterior teeth have lingual surfaces, which are anatomically inclined shaped. If a lingual rest is positioned on the lingual surface of the anterior tooth, the sloped surface acts as an inclined plane. When the vertical force is applied on the object along the inclined plane, the two vectors of this force can cause the movement of the rest and a lateral force exertion on the tooth. A proper rest seat should be prepared to transmit the forces along the vertical axis of the teeth to prevent lateral forces. Instead of the anterior teeth, it would be better to prepare a cingulum rest seat on the lingual surface of the canines, which are more resistant to the lateral forces because of their greater root surface area. In clinical practice, proper lingual or cingulum rest seat preparations on the lingual surfaces can be provided with the aid of a bonded composite resin (see Chap. 10).

4.2.2.2 The Lever

A lever is a simple mechanical machine that consists of a rigid rod, which is pivoted at a fixed fulcrum. The lever rotates around the fulcrum and amplifies an input force (effort) to provide a greater output force (resistance) that is called the leverage. In terms of dental biomechanics, the denture rotates around a fulcrum when it is displaced from the basal seat. During the rotational movement, the resistance is provided by a direct retainer or a guiding plane surface, whereas fulcrum is the tooth surface, such as an occlusal rest, and the input force is the occlusal force or the gravity itself.

In mechanics, levers are classified into three types according to the positions of the fulcrum, effort, and resistance forces. The function of the lever varies according to these three types:

In Class I lever, fulcrum is located in the middle in between the load and the exerted effort (Fig. 4.5). A typical seesaw movement occurs with this type of leverage. A pair of scissors is another example for Class I levers. Class I lever type is the most efficient lever when a great output force (resistance) load is to be lifted with little effort (occlusal effort)

In Kennedy Class I and II cases, Class I type lever is formed when a disto-occlusal rest (fulcrum) is placed on the most distal abutment tooth with a circumferential clasp (resistance) (Fig. 4.6). When an occlusal load is applied on the extension base, the retentive tip of the circumferential clasp will move along the undercut area that will result in a distally tipping movement of the abutment tooth. With the great efficiency of the class I lever system, the higher torque will be applied on the abutment tooth with disto-occlusal rest, which will negatively affect the prognosis of the abutment tooth. Another type of Class I leverage formed in RPD design is to get support only from one tooth in one side of the arch that acts like a cantilever in Kennedy Class I and II cases. This design should always be avoided. To eliminate or reduce the possible torque on the abutment teeth, Class II type

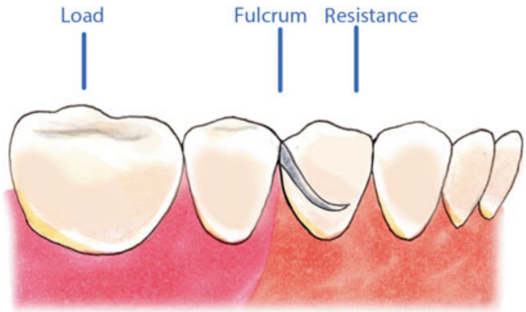

Fig. 4.6 In Kennedy Class I and II cases, Class I type leverage is formed when a disto-occlusal rest (fulcrum) is placed on the most distal abutment tooth with a circumferential clasp (resistance)

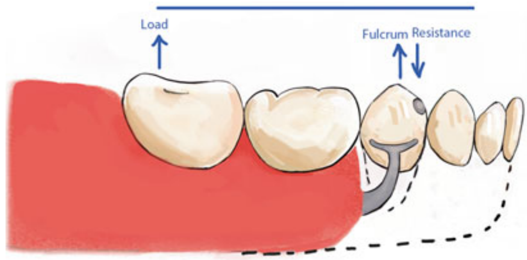

Fig. 4.8 In Kennedy Class I and II cases, Class II type leverage is formed when a mesio-occlusal rest (fulcrum) is placed on the most distal abutment tooth with a bar clasp (resistance) under occlusal or gravitational forces. In this design, the efficiency of the lever is reduced with the smaller movement of the extension base that will apply less torque on the abutment tooth

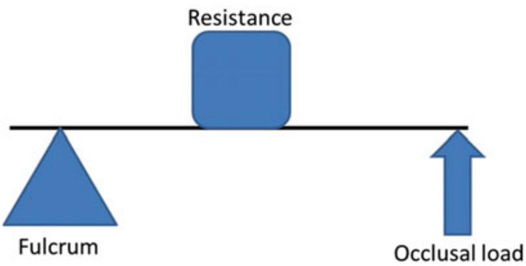

Fig. 4.7 Class II type leverage system. Resistance is positioned in the middle in between the fulcrum and the exerted effort

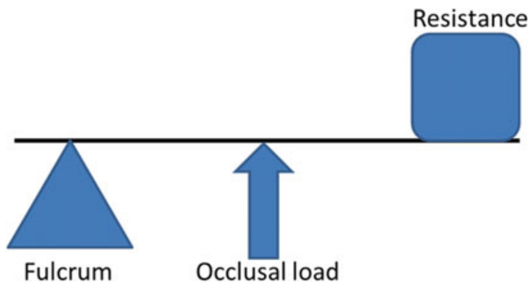

Fig. 4.9 Class III type leverage system. Exerted effort is applied in the middle in between the fulcrum and the resistance

leverage system is to be formed during treatment planning.

In Class II type lever, resistance is positioned in the middle in between the fulcrum and the exerted effort (Fig. 4.7). A wheelbarrow or a nutcracker is a typical example for this type of lever. With less movement, Class II type lever is a less efficient lever than Class I.

In Kennedy Class I and II cases, Class II type lever is formed when a mesio-occlusal rest (fulcrum) is placed on the most distal abutment tooth with a bar clasp (resistance) under occlusal or gravitational forces (Fig. 4.8). In this design, the efficiency of the lever is reduced with the smaller movement of the extension base that will apply less torque on the abutment tooth.

In Class III levers, exerted effort is applied in the middle in between the fulcrum and the resistance (Fig. 4.9). The human mandible or tweezers are examples for Class III levers. Class III lever is the least efficient type of lever, where the movement is at minimum with the same exerted force. Class III type lever system is formed in tooth-supported RPDs, where a disto-occlusal rest (fulcrum) is placed on the mesial abutment tooth and a circumferential clasp on the distal abutment tooth (Fig. 4.10).

4.2.2.3 Mechanical Advantage

The effectiveness of the lever is calculated by the mechanical advantage (MA) that is the ratio of the distance between the fulcrum and the load that is called the load arm (a) to the distance between the fulcrum and the resistance that is called the effort arm (b) (Fig. 4.11).

The greater the MA, the less effort is required to provide a bigger movement. Clinically speaking, in Kennedy Class I and II and Kennedy IV class with long edentulous span cases, the MA is the ratio of the distance between the rest and the

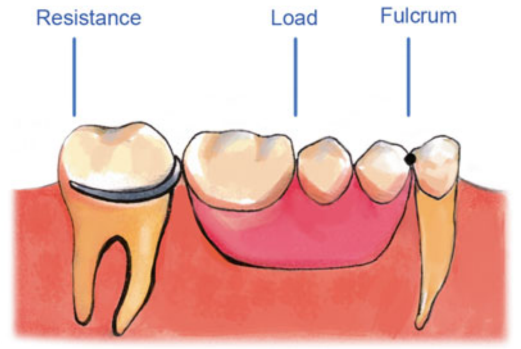

Fig. 4.10 In Kennedy Class III cases, Class III type lever system is formed, where a disto-occlusal rest (fulcrum) is placed on the mesial abutment tooth and a circumferential clasp on the distal abutment tooth

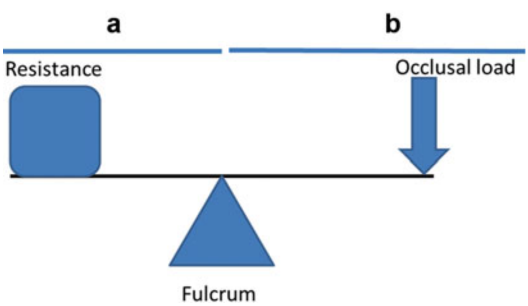

Fig. 4.11 The mechanical advantage is the ratio of the distance between the fulcrum and the effort that is called the effort arm (*a*) to the distance between the fulcrum and the load that is called the load arm (*b*). In Kennedy Class I and II and Kennedy Class IV with long edentulous span cases, the mechanical advantage is the ratio of the distance between the rest and the edentulous span (*b*) to the distance between the rest and the retentive tip of the clasp (*a*). The greater the mechanical advantage, the longer the edentulous span and the greater displacement of the denture base (an undesirable condition for an RPD). The displacement of the denture is the result of a rotational movement of the RPD around the horizontal fulcrum line extending through the rests on the most distally placed abutment teeth

edentulous span (the most distal point of the denture base to the rest) to the distance between the rest and the retentive tip of the clasp. The greater the MA, the longer the edentulous span and the greater displacement of the denture base, and that is an undesirable condition for an RPD. The displacement of the denture is the result of a rotational movement of the RPD around the horizontal fulcrum line extending through the rests on the most distally placed abutment teeth.

4.3 The Displacement of the RPD

Rotational movement causes the RPD to displace in two directions:

1. Movement towards the tissue
2. Movement away from the tissue

4.3.1 Movement Towards the Tissue

In Kennedy Class I and II cases, the rotational movement of the RPD is complex and dynamic. This rotational movement must be controlled but cannot be completely eliminated. In these cases, the denture rotates around the most distal abutment teeth. If the chewing force is applied on the denture base, the major connector and the retentive tip of the clasp will move in the opposite direction to provide a balance for the Class I type lever, acting like a seesaw. The retentive tip of the clasp will move upwards along the survey line, while the proximal part will move towards the anterior. The movement of the clasp assembly will create torque on the abutment teeth, which are laterally subjected to the vectors of the forces. In other words, during the movement towards the tissue, the rest will act as a fulcrum, and all the components of the RPD posterior to the rest (fulcrum) will move towards the tissue, while all the components of the RPD anterior from the rest, including the tip of the direct retainer, will move away from the tissue. The tip of the clasp in the undercut will apply lateral force to the abutment tooth. In addition, the lateral forces may also be compensated if an adjacent tooth contacting the abutment teeth at the mesial side is present. A Class II type leverage system is to be formed to minimize the displacing movement of the denture base. If a rest is placed on the mesial of the abutment teeth, the Class II type lever is formed where the retentive tip of the direct retainer (resistance) is located in between the rest (fulcrum) and the chewing force. When the chewing force is applied on the denture base, the RPD rotates around the mesially positioned fulcrum. If a disto-occlusal rest is placed on the most distally positioned abutment teeth, the greater displacement of the denture base should be

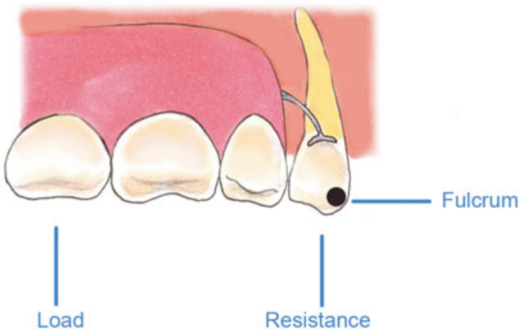

Fig. 4.12 When a sticky food is consumed, the denture will tend to move away from the tissue. During the movement of the RPD away from the tissue, the fulcrum line passes from the tips of the direct retainers but not the rests. All of the components of the RPD posterior to the tip of the direct retainer (fulcrum) will move away from the tissue, while all the components of the RPD anterior to the tip of the direct retainer will impinge on the tissue

Fig. 4.13 To prevent the movement of the RPD away from the tissue, indirect retainers should be added to the RPD design so that the indirect retainer will act as a fulcrum and limit movement of the anterior part of the RPD by serving as a Class II type leverage system. To balance the displacement of the denture base, indirect retainers should be positioned as much farther to the most distal abutment

expected due to the Class I type leverage, which will easily cause the denture base to displace and apply torque on the abutment teeth with possible traumatization on the residual ridges.

4.3.2 Movement Away from the Tissue

When a sticky food is consumed, the denture will tend to move away from the tissue (Fig. 4.12). During the movement of the RPD away from the tissue, the fulcrum line passes from the tips of the direct retainers but not the rests. In other words, all the components of the RPD posterior to the tip of the direct retainer (fulcrum) will move away from the tissue, while all the components of the RPD anterior to the tip of the direct retainer will impinge on the tissue. To prevent the movement of the RPD away from the tissue, indirect retainers should be added to the RPD design so that the indirect retainer will act as a fulcrum and limit movement of the anterior part of the RPD by serving as a Class II type leverage system. To balance the displacement of the denture base, indirect retainers should be positioned as much farther to the most distal abutment (See Chap. 11) (Fig. 4.13).

In tooth-tissue-supported cases, such as Kennedy Class I and II cases and Kennedy Class IV cases with long edentulous span, forces will be transmitted to the edentulous soft tissue and the periodontal ligament of the abutment tooth. Because the soft tissues are 250 times more displaceable than the adjacent teeth, Class I type of levers should be converted to Class II and III types of levers by adding additional components, such as indirect retainers, placing posterior dental implants. In clinical practice, the choice of the altered-cast impression technique may also be effective in the minimization of the displacement of the denture by increasing the support for the base, decreasing the forces on the abutment tooth, and protecting the gingival mucosa of the abutment tooth. In addition, maximum coverage of the soft tissues to distribute the forces is also effective to protect the supporting structures. It should be noted that the ideal design of an RPD should focus on protecting both the abutment teeth and the residual ridge in an attempt to distribute the occlusal forces on them.

Class III type of lever is formed in tooth-supported Kennedy Class III and Kennedy Class IV with short span classified cases. In tooth-supported cases, the rotational movement depends on the resiliency of the periodontal ligament. In tooth-supported RPDs, movement towards the tissue is primarily prevented by the rests on the abutment teeth. In these cases, the rigid portion of the framework and rigid component of the direct retainer are also helpful in the prevention of this movement. The movement of the tooth-supported RPDs away from the tissue is prevented by the action of direct retainers.

A biomechanically alternative solution to prevent the rotational movement of the RPD is to place dental implants to the distal extension sites so that the case can be converted from tooth-tissue-supported to implant-supported RPDs. The placement of the free-standing dental implant at the distal region of the edentulous ridge can prevent the rotational movement of the distally extended RPD and reduce the pressure on the edentulous molar region. To obtain maximal support and stability, the implant should be positioned as distally as possible for Kennedy Class I and II cases, while in Kennedy Class IV partial edentulous cases, implants should be located as medially as possible. The use of implant support in Kennedy Class III cases can only be considered in cases with extended edentulous span or with the need of the elimination of the undesirable appearance of the clasps. In these cases, the implants should be placed adjacent to the abutment teeth as possible. Use of stress-breaking attachments, such as ERA attachment, and locator attachments have been suggested to protect the implants from the excessive forces that have been observed in implant-supported RPDs. It has also been reported that implant placement at the distal region of the mandibular edentulous ridge can prevent the displacement of the denture, regardless of the denture-supporting area. This finding suggests that shorter denture periphery with no need of maximal coverage of the edentulous ridge is not necessary for implant-assisted RPDs. Although this treatment modality could represent a low-cost, biomechanically beneficial approach with improved patient satisfaction for distal extension RPDs, further studies are strictly needed to validate the clinical outcomes (see Chap. 17).

4.4 Factors That Are Related to the Force Transfer to the Abutment Teeth and the Residual Ridges

Stress transmitted to the abutment teeth and the residual ridges may cause clinical problems such as periodontal damage, irritation of the mucosa, and patient discomfort. The understanding of the factors related to the stress transmission to the denture-supporting structures is important for treatment planning for RPDs.

4.4.1 The Residual Ridge Support

Maximal support and good adaptation of the denture base in distal extension RPDs is the most important clinical factor regarding residual ridge support. The occlusal load on the RPD, especially in Kennedy Class I and II cases, is shared between the abutment teeth and the residual. In a photoelastic study, due to the shared loads between the residual ridge and the abutment teeth, lower stress intensity with more uniform stress distribution on the abutment teeth was obtained with the RPD when compared to a fixed partial denture with a cantilever design.

The resiliency of the abutment teeth and the edentulous mucosa has been the subject of many studies in the literature. The difference in resiliency causes a rotational displacement of the distal extension of the RPD around the most distal abutment teeth. The thickness and the resiliency of the edentulous mucosa play a role in the load transfer to the abutment teeth. A mucosal thickness of approximately 1 mm can bear a functional occlusal force, while a thin, atrophic, or flabby characterized edentulous mucosa may not provide vertical support; thus, increased displacement of the denture and stress transmission to the abutment teeth should be expected. It seems clinically important that functional impression techniques should be applied to reflect the resiliency of the supporting structures. A clinical study reported a 0.19 mm of vertical displacement, as being the lowest value, of the RPDs fabricated using the altered-cast impression technique compared to the impressions with border-molded custom tray and a stock tray with irreversible hydrocolloid. The same trend was observed in another study which suggested no superior influence of the altered-cast impression technique that produced a 0.15 mm of discrepancy between the denture base and the mucosa. Nevertheless, clinical significance of only a 0.15–0.19 mm difference in the vertical direction obtained with the altered-cast impression technique should be questioned. Further clinical studies focusing on the influence of the resiliency as well as the impression techniques on the stress distribution to the abutment teeth and the residual ridges are required.

Another factor related to the residual ridge support is the form of the alveolar ridges. Large, parallel-sided, broad-sectioned ridges can provide vertical ridge support than the thin, knife-edged, or resorbed ridges to resist lateral forces and thus the transmission of the lateral forces to the abutment teeth. In distally extended maxillary RPDs, large vertical movement of the maxillary denture base was also associated with a large buccal movement of the abutment tooth.

4.4.2 The Length of the Edentulous Span

The rotational movement of the denture base will lead to the transmission of the load to the abutment teeth. As mentioned above under the mechanical advantage title, as the edentulous span gets longer, the greater displacement of the denture base should be expected.

4.4.3 The Periodontal Support of the Abutment Teeth

The resultant forces with both lateral and vertical vectors arising from the displacement of the denture will be applied on the abutment teeth. The periodontal support to withstand the resultant forces is of clinical importance. A 35 % loss of periodontal support has been shown to increase the stress concentration in bilaterally distal extension maxillary RPDs. In a photoelastical study, it was shown that the highest stress concentrations were observed with the model that had the least periodontal support. In addition, fixed splinting of the distal abutment teeth was more pronounced when the amount of the periodontal support decreased. On the other hand, it was also reported that the number of splintings was not directly proportional to the stress transmitted. However, it was also reported that when an additional tooth was splinted to the most distal two abutment teeth, the force was transmitted to the most distal abutment tooth more axially in uniformed distributed characteristics. Although it is conventionally believed that the number of fixed splinted teeth will proportionally reduce the stress transmitted to the abutment teeth, the literature seems to be lacking of evidence about the effect of splinting of abutment teeth either with normal or reduced periodontal support.

4.4.4 The Design of the RPD

The design of the RPD has always been the subject of many biomechanics studies. An in vivo 3D study showed that the force on the abutment teeth was lowered with wearing the RPD than without wearing the RPD.

Many previous studies suggested that the rigid major connectors can reduce the stress concentration on the abutment teeth and the residual ridges by distributing the occlusal forces across the dental arch. In a Kennedy Class II mod 1 scenario, higher stress in the abutment teeth and on the residual ridge was observed with an RPD design with polyacetal resin framework (due to the nonrigid characteristics of the polyacetal resin) than an RPD design with a conventional metal framework. The same trend in stress distribution was observed in another study that reported decreased movement of abutment teeth and denture base with the conventional cobalt-chrome framework than the metal-reinforced acrylic resin framework. The rigidity of the RPD design seems to positively affect the dynamics of the denture.

The use of a lingual plate as a major connector has been suggested so that it can stabilize the abutment teeth by altering the direction of the occlusal forces.

Although the use of mesial rests is a theoretically established point of view regarding the leverage effects, the findings of some studies indicated no superior advantage with mesial rest over distal rests. On the other hand, an RPD design without the rests turns up with poor biomechanical results.

There is still no clear consensus about the ideal RPD design for stress distribution to the abutment teeth and the residual ridge.

4.4.5 The Design of the Direct Retainer

The design of a direct retainer is considered as an important factor on the force transmitted to the abutment teeth and the residual ridges.

The rigidity of the direct retainers has a significant effect on the transmission of the force to the abutment teeth and the vertical displacement of the RPD.

When compared to rigid designs on distal extension-based RPDs, such as conical telescopic crowns, a wrought wire clasp conducts less stress to the abutment teeth, while allowing an increased stress transmission to the residual ridges. Akers type clasps stand between these two retainer designs ragarding the distribution of stress between the abutment teeth and the residual ridges. In a 6-month clinical follow-up, no significant changes were observed in the mobility of the abutment teeth with a T-clasp for unilateral and bilateral distal extension cases and cast circumferential clasp for tooth-supported cases. A clasp-retained design applies less torque on the abutment teeth than the intracoronal precision attachments. The reason of the reduction of the stress concentration on the residual ridges for the rigid design was related to the transmission of the force along the long axis of the abutment teeth. Moreover, an RPI clasp design (with mesial rest seat and buccal I-bar) has been shown to produce less torque on the abutment teeth than the circumferential clasp. In addition, in experimental model studies, nonrigid wire clasp was found to have an association with an increased buccal movement of the abutment tooth than the rigid designed retainers. A randomized clinical trial reported that there was no significant difference between the circumferential and bar clasps on the periodontal health of abutment teeth and success rates and maintenance of RPDs.

It seems that the rigid type direct retainer is better for residual ridge maintenance with minimal need of tissue support. On the other hand, stress transfer to the abutment tooth seemed to increase with the rigidity of the direct retainer, showing that the stress-releasing type of direct retainer theory does not work.

These findings suggest the consideration of maintenance of the denture-supporting structures during treatment planning. It should be noted that further controlled clinical trials and randomized studies are required regarding the effect of the design of the direct retainer.

4.4.6 The Antagonist Dentition

The antagonist occluding forces acting on the denture base of the RPD may influence the load transmission to the abutment teeth. The amount of the load transferred varies from being intact to completely edentulous.

The findings of these studies suggest that if a correct treatment planning is done with the understanding of the biomechanical aspects, high success rates and patient comfort should be expected with a well-constructed RPD with a logical design.

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5 Diagnosis and Treatment Planning in Partially Edentulous Patients

Tonguç Sülün and Olcay Şakar

5.1 Definitions

Canine guidance A form of mutually protected articulation in which the vertical and horizontal overlap of the canine teeth disengage the posterior teeth in the excursive movements of the mandible.

Centric stop Opposing cuspal/fossae contacts that maintain the occlusal vertical dimension between the opposing arches.

Contralateral Occurring on or acting in conjunction with similar parts on an opposite side.

Cross-arch stabilization Resistance against dislodging or rotational forces obtained by using a partial removable dental prosthesis design that uses natural teeth on the opposite side of the dental arch from the edentulous space to assist in stabilization.

Diagnostic cast A life-size reproduction of a part or parts of the oral cavity and/or facial structures for the purpose of study and treatment planning.

Eccentric interocclusal record A registration of any maxillomandibular position other than centric relationship.

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Group function Multiple contact relations between the maxillary and mandibular teeth in lateral movements on the working side whereby simultaneous contact of several teeth acts as a group to distribute occlusal forces.

Interim prosthesis A fixed or removable dental prosthesis, or maxillofacial prosthesis, designed to enhance esthetics, stabilization, and/or function for a limited period of time, after which it is to be replaced by a definitive dental or maxillofacial prosthesis. Often such prostheses are used to assist in the determination of the therapeutic effectiveness of a specific treatment plan or the form and function of the planned for definitive prosthesis.

Laterotrusion Condylar movement on the working side in the horizontal plane. This term may be used in combination with terms describing condylar movement in other planes, for example, laterodetrusion, lateroprotrusion, lateroretrusion, and laterosurtrusion.

Maximal intercuspal position (MIP) The complete intercuspation of the opposing teeth independent of condylar position, sometimes referred to as the best fit of the teeth regardless of the condylar position—also called maximal intercuspation.

Mediotrusion A movement of the condyle medially.

Mounting The laboratory procedure of attaching a cast to an articulator or cast relater. The relationship of dental casts to each other and the instrument to which they are attached.

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Nonworking side That side of the mandible that moves toward the median line in a lateral excursion. The condyle on that side is referred to as the nonworking side condyle.

Occlusal adjustment Any change in the occlusion intended to alter the occluding relation; any alteration of the occluding surfaces of the teeth or restorations.

Occlusal analysis An examination of the occlusion in which the interocclusal relations of mounted casts are evaluated.

Occlusal units/pairs A pair of antagonist teeth that support the occlusion. One occlusal unit corresponds to a pair of occluding premolars; a pair of occluding molars corresponds to two occlusal units.

Premature contact A contact that displaces a tooth, diverts the mandible from its intended movement, or displaces a removable denture from its basal seat.

Retruded contact position (RCP) That guided occlusal relationship occurring at the most retruded position of the condyles in the joint cavities. A position that may be more retruded than the centric relation position.

Retrusion Movement toward the posterior.

Shortened dental arch Having an intact anterior region but a reduced number of occluding pairs of posterior teeth or a dentition with a reduction of teeth starting posteriorly.

Supra-eruption Movement of a tooth or teeth above the normal occlusal plane.

Supporting cusps Those cusps or incisal edges of teeth that contact in and support maximum intercuspation. Usually facial cusps of the mandibular posterior teeth, the maxillary palatal cusps, and the incisal edges of the mandibular anterior teeth.

Splint (1) A rigid or flexible device that maintains in position a displaced or movable part, also used to keep in place and protect an injured part; (2) A rigid or flexible material used to protect, immobilize, or restrict motion in a part.

Working side The side toward which the mandible moves in a lateral excursion.

Patients generally visit a dental office not to receive a removable partial denture (RPD) but to resolve the functional and/or esthetic problems or pain. Thus, the primary challenge of the clinician is to understand the needs and the expectations of the patient. In order to obtain a unique treatment plan, evaluation of the patient's medical and dental history, financial capability, behavioral and socioeconomic profiles, a full-mouth series of periapical and panoramic radiographs, a complete clinical examination, and proper diagnostic casts that have been transferred to a semi-adjustable articulator using face bow (when necessary) and interocclusal records are required (Fig. 5.1a–e).

However, dental students and new graduates often find it extremely difficult to register the assembled diagnostic data for patients with complex problems and develop a logical treatment plan that will correspond to the patient's needs. This is a very well-known story: an extremely supra-erupted tooth of a partially edentulous patient is treated endodontically and periodontally, followed by a metal-ceramic restoration that is made, all in order to receive a final RPD. The abovementioned clinical procedures take too much time and money, yet at the end when designing an RPD, it is "surprisingly" observed that the tooth couldnot be used as an abutment for the prosthesis. Needless to say, all the pretreatment stages applied to the patient turn out to be unnecessary. This tooth had to be extracted in the first place. Such a situation is very disappointing for the patient and waste of time and money for both the doctor and the patient. Therefore, the treatment plan and decision-making has to be established prior to any treatment, including even a simple filling or an extraction (Fig. 5.2a–d).

There are two basic questions to answer when planning a treatment for a partially edentulous patient:

- What to do with the existing teeth of the patient?
- What does the patient expect from us?

The answer to the second question is always the most critical. In a survey of Todd and Lader (1991), 79 % of adults over 65 years of age with natural dentition answered the question "If you had several missing teeth at the back, would you prefer to have a partial denture or manage without?" that they prefer to manage without a partial denture. Interestingly in younger people (16–24 years of age), this percentage was only 52 when asked the same question. Similarly in the same survey 27 % of the senior people (65 and over) found the thought of having a partial denture to replace some of their teeth "very upsetting," whereas the younger people were less worried about this option (16 %). A possible reason for this trend could be that young people cannot relate themselves to such an experience. Actually, young partially edentulous patients prefer almost always a fixed partial denture alternative. Therefore, for both young and old patients, the RPD option (or necessity thereof) needs to be explained thoroughly by using demonstration models. To explain the patients the possible treatment alternatives at hand, diagnostic models transferred to an articulator appear to be the most rational way.

5.2 Diagnostic Models and Occlusal Analysis

5.2.1 The Importance of Diagnostic Models

There are certain limits to the information that can be accumulated through clinical examination and radiographs. So study models give us valuable additional information about the clinical status. To start with, study models reveal a three-dimensional representation of the oral situation alongside with a lingual view of the occlusion (Fig. 5.3a, b). A patient who visits a dental clinic with partial edentulism may just seek the treatment of the painful tooth/teeth. At times, the patient may have esthetic and/or functional complains which require a complex treatment. In such cases, study models transferred to a semi-adjustable articulator are needed in order to plan a treatment for the patient in question. These

Fig. 5.1 (**a**) A patient with severely worn dentition in maximal intercuspal position (MIP). (**b**) Occlusal view of the mandibular arch. (**c**) Occlusal view of the maxillary arch. (**d**) The periapical radiographs of the patient. (**e**) The diagnostic models are mounted to a semi-adjustable articulator

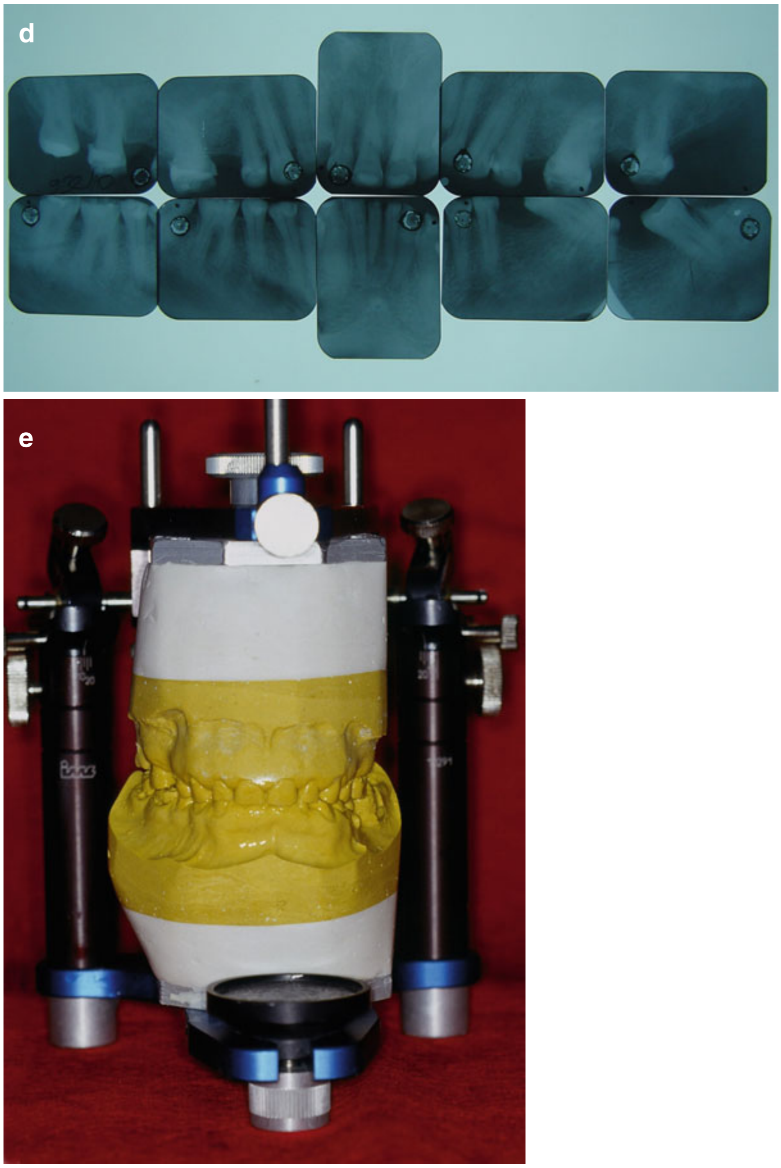

Fig. 5.1 (continued)

models are useful not only for decision-making but also for communicating and consulting with several other specialists (e.g., periodontist, orthodontists, dental surgeon, or dental technician), not to mention the ease of demonstrating the oral status and the treatment options to the patient (Fig. 5.4a–f).

Once the models are prepared, they can be mounted to some form of an articulator or can be held by hand in intercuspal position without using any device. Out of these three options, the choice for how to proceed can be made according to the following data on the needs of the patient.

Unmounted Study Models
When

- To assess static interarch relationships where there are sufficient occluding teeth
- To assess single arch problems

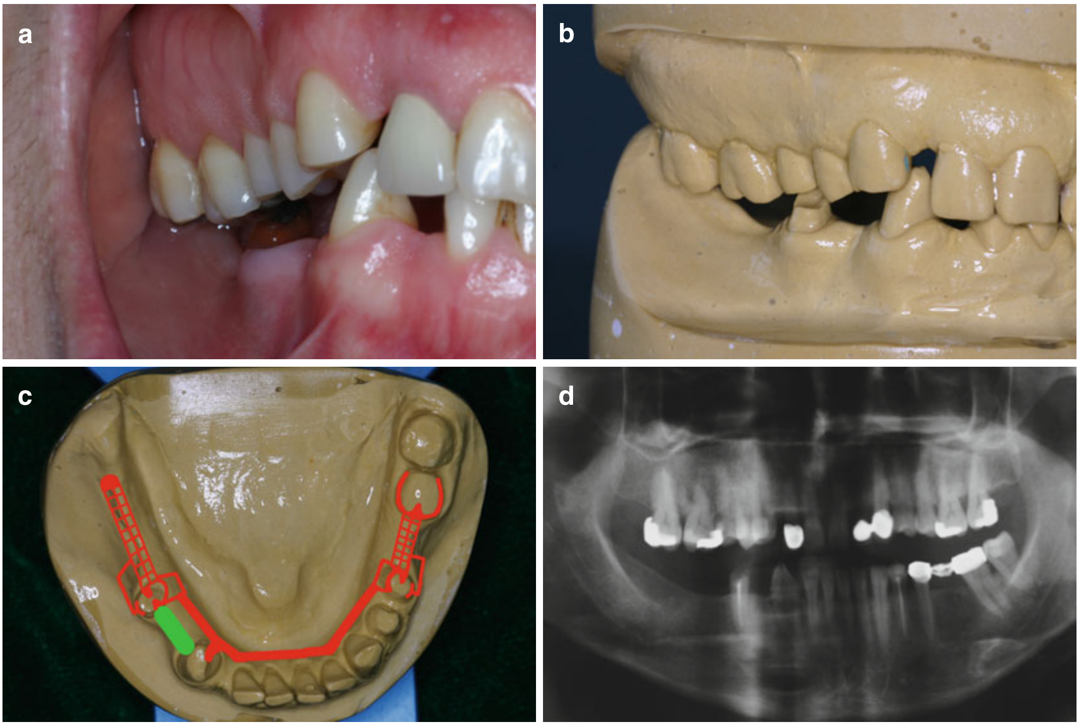

Fig. 5.2 (**a**) A patient with extreme growth of the periodontal tissues in an occlusal direction including the alveolar bone, together with the teeth. (**b**) The diagnostic casts are mounted to a semi-adjustable articulator. However there is no place for the prosthesis' posterior part. (**c**) The planning of the mandibular removable partial denture design. (**d**) The panoramic radiograph of the patient

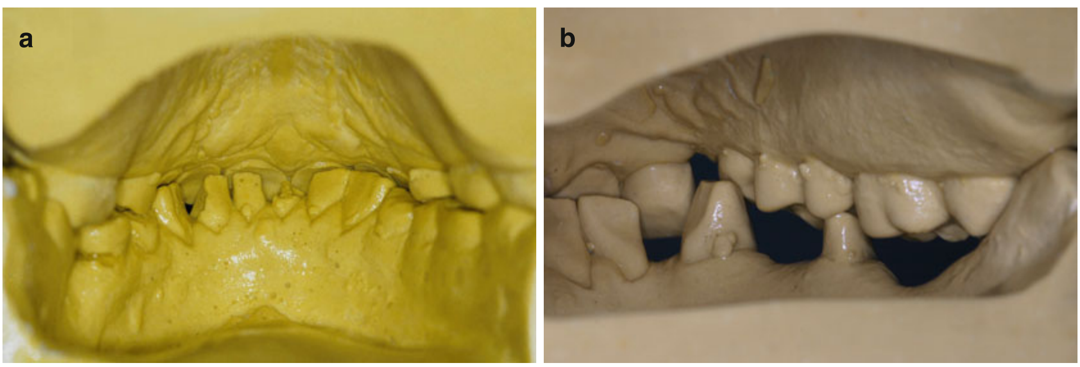

Fig. 5.3 (**a**) The lingual view of the models of the patient mentioned in Fig. 5.1. (**b**) The lingual view of the models of the patient

Mounted Study Models on a Hinge Type Articulator

When

- To assess static interarch relationships where there are insufficient occluding teeth
- To analyze cases with small unit fixed partial denture within an acceptable occlusion

Mounted Study Models on Semi-adjustable Articulator

Where

- Any major prosthodontic treatment is required
- Any increase of occlusal vertical dimension is required

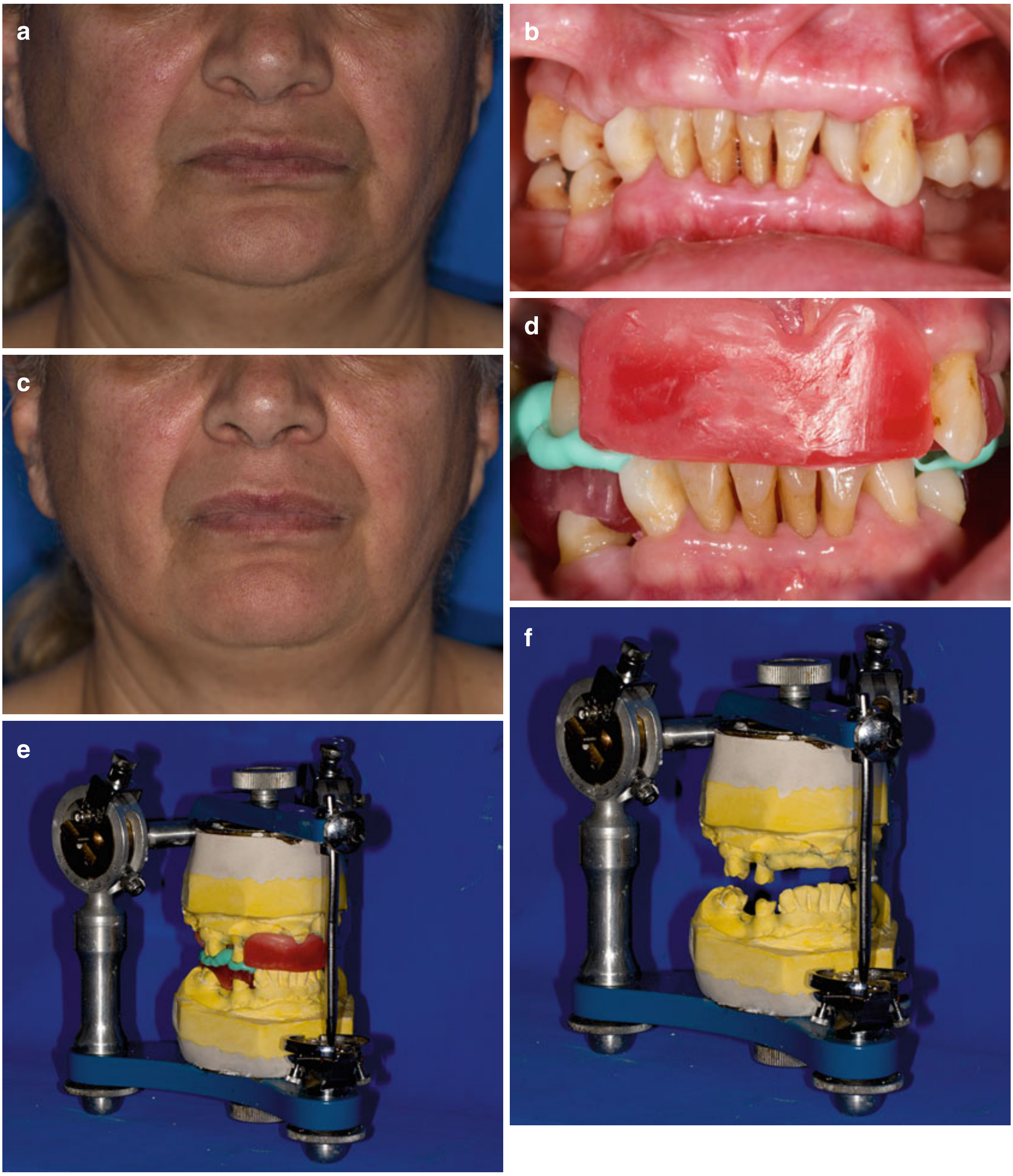

Fig. 5.4 (**a**) The facial view of the patient with severely decreased occlusal vertical dimension. (**b**) The intraoral view of the patient in maximum intercuspal position (MIP). (**c**) The facial view of the patient with increased occlusal vertical dimension. (**d**) An increased occlusal vertical dimension and centric relation record is completed using base plates and occlusion rims. (**e**) The records are transferred to a semi-adjustable articulator. (**f**) The models mounted to the articulator are ready to analyze and plan the new prosthodontic work. Please notice the enormous interocclusal distance

- A significant discrepancy in maximum intercuspal position (MIP) and retruded contact position (RCP) is present
- There is a need to create a new occlusal relationship

5.2.2 The Impression and Casts for Study Models

Most of the clinicians have a tendency to believe that the primary impressions and study models can be prepared without too much effort and attention. They believe that a study model does not need to be as correct as a master model, which is absolutely wrong. Without any exception, these diagnostic models have to reflect all the details of the hard and soft tissues. Therefore, it is definitely incorrect to assume that only the evaluation of the dentition or a part of the dentition or the residuel ridges are sufficient to make a treatment planning. A study model should contain the following:

- Sufficient occlusal surfaces for an occlusal analysis
- Sufficient axial surfaces and soft tissue parts for making an analysis on a parallelometer (surveying) to find the path of insertion and the undercuts
- Sufficient residual ridges for preparing a well-fitting interim prosthesis (a temporary FPD, RPD, or an immediate denture)

It is usually enough to use a metal stock tray and an alginate for the primary impression of a partially edentulous patient. But sometimes the stock trays should be modified using wax or compound. To have a satisfactory impression of occlusal surfaces, non perforated rim-lock trays with tray adhesive should be preferred. Finally, a bubble-free impression that contains all parts of the dentition and residual ridges should be poured with Class III dental stone by the clinician himself/herself to avoid a potential syneresis phenomenon.

5.2.3 Using the Diagnostic Casts for Decision-Making

As an additional option, the diagnostic casts transferred to the semi-adjustable articulator may well be used with other diagnostic tools like radiographs, anamnesis, and clinical examination. But first of all, the clinicians have to decide to either extract the tooth/teeth or restore it. Therefore, we need to analyze the periodontal and coronal status of the teeth, the relationship of each tooth to the occlusal plane, and the existing occlusion in details. Thereafter, to arrive at a rational treatment planning, all these data should be combined and checked against the expectations, financial condition, general health, and age of the patient.

5.2.3.1 Periodontal Status

A proper clinical and radiographic examination is needed to decide on periodontal therapy or extracting the tooth/teeth. This decision, however, is mostly dependent on the following:

- The periodontal destruction level of the tooth/teeth. (In case of a hopeless tooth, we need to consider that an RPD will aggravate the periodontal status of the teeth.)
- Do we use the tooth/teeth as an abutment for the RPD? (In which case a better periodontal health is required.)
- Is the tooth/teeth inevitable for the RPD? (For example, a single maxillary or mandibular single anterior tooth with a moderate periodontal status is not useful as an abutment in all cases.)
- The motivation of the patient toward his/her oral hygiene (RPDs have a negative effect on oral hygiene. So if the patient is not able or not motivated about his/her oral hygiene, the periodontal therapy should be reconsidered.)

5.2.3.2 Coronal Status

A proper clinical and radiographic examination is needed to decide for making a restoration or extracting the tooth/teeth. This decision is also dependent on the following:

- Are the tooth/teeth restorable? (For example, a severely damaged tooth is not useable as an abutment where a ferrule construction is impossible.)
- Do we use the tooth/teeth as an abutment for the RPD? (An abutment tooth for a bridge or an RPD should comprise sufficient resistance. To name an example, a tooth which can only be restored with apical resection, may otherwise be well held in the mouth for years and will not lend itself a good choice as an abutment.)
- Is the tooth/teeth inevitable for the RPD? (For example, a restorable, single maxillary second

molar tooth could better be extracted, and a complete denture will be the preferred choice in cases with insufficient residual ridges.)
- The oral habits of the patient (for example if the patient has bruxism, oversized restorations are questionable).
- Supra-erupted or tilted teeth. (This kind of teeth should be analyzed on an articulator in both centric and eccentric positions. When analyzed only in centric occlusion, a tilted or supra-erupted tooth may sometimes seem utilizable after some preparations. However, if analyzed in eccentric occlusion, especially in protrusive and/or mediotrusive movement, it comes out that the premature contacts are not correctable with occlusal equilibration or not even with an FPD. Thus, one or more orthodontic, endodontic, and periodontal treatment modalities need to be applied before the definitive prosthodontic treatment. Even seldomly, the extraction of the tooth may remain as the only choice.)

On the study model, the tooth is grinded until it attains a proper occlusal clearance both in centric and eccentric occlusion. After that, the tooth should be adjusted to have a perpendicular axis. To make the clinical decision for an FPD, the amount of the preparation should only be analyzed afterwards. These pretreatment modalities will be discussed in Chapter 21 and 22 in details.

5.2.3.3 Analysis of the Existing Occlusion

Prior to any kind of extensive restorative procedure, occlusal analysis and if necessary an occlusal adjustment should be prepared, with the general exemption (not a rare case) of a healthy masticatory system which is free of any kind of dysfunctional signs and/or symptoms. The pretreatment modalities will be discussed in Chapter 21. There are two basic reasons why the occlusal adjustments need to be done primarily in study models transferred to a semi-adjustable articulator:

- To observe if just an occlusal equilibration is sufficient or should we better restore the teeth
- To create an appropriate chart ahead of any occlusal adjustment in the mouth of the patient

5.2.3.4 Deciding the Type of the Prosthesis

To make a proper treatment planning in a partially edentulous patient, the clinician needs to analyze a wide range of physical variations and health conditions. Therefore using an organized guideline for diagnostic criteria will be very helpful for the dental professionals. The American College of Prosthodontists (ACP) has developed a Classification System for Partial Edentulism in 2002. This system is constructed basically on four issues:

- Location and extent of the edentulous areas
- Condition of the abutment teeth
- Occlusal scheme
- Residual ridge characteristics

These issues are then classified as ideally or minimally, moderately, substantially, and severally compromised.

Classification System for Partial Edentulism

Location and Extent of the Edentulous Areas

- Ideally or minimally compromised
- Any anterior maxillary edentulous area that does not exceed 2 incisors
- Any anterior mandibular edentulous area that does not exceed 4 incisors
- Any posterior maxillary or mandibular edentulous area that does not exceed 2 premolars or 1 premolar and 1 molar
- Moderately compromised
- Any anterior maxillary edentulous area that does not exceed 2 incisors
- Any anterior mandibular edentulous area that does not exceed 4 incisors
- Any posterior maxillary or mandibular edentulous area that does not exceed 2 premolars or 1 premolar and 1 molar
- A missing maxillary or mandibular canine
- Substantially compromised

- Any posterior maxillary or mandibular edentulous area greater than 3 teeth or 2 molars
- Any edentulous areas including anterior and posterior areas of 3 or more teeth
- Severely compromised
- Any edentulous area or combination of edentulous areas requiring a high level of patient compliance

Condition of the Abutment Teeth

- Ideally or minimally compromised
- No preprosthetic therapy is indicated.
- Moderately compromised
- Abutments in 1 or 2 sextants have insufficient tooth structure to retain or support intracoronal or extracoronal restorations.
- Abutments in 1 or 2 sextants require localized adjunctive therapy (i.e., periodontal, endodontic, or orthodontic procedures).
- Substantially compromised
- Abutments in 3 sextants have insufficient tooth structure to retain or support intracoronal or extracoronal restorations.
- Abutments in 3 sextants require more substantial localized adjunctive therapy (i.e., periodontal, endodontic, or orthodontic procedures).
- Severely compromised
- Abutments in 4 or more sextants have insufficient tooth structure to retain or support intracoronal or extracoronal restorations.
- Abutments in 4 or more sextants require extensive adjunctive therapy (i.e., periodontal, endodontic, or orthodontic procedures).
- Abutments have guarded prognoses.

Occlusal Scheme

- Ideally or minimally compromised
- No preprosthetic therapy is required.
- Class I molar and jaw relationships are seen.
- Moderately compromised
- Occlusion requires localized adjunctive therapy (e.g., enameloplasty on premature occlusal contacts).
- Class I molar and jaw relationships are seen.
- Substantially compromised
- Entire occlusion must be reestablished but without any change in the occlusal vertical dimension.
- Class II molar and jaw relationships are seen.
- Severely compromised
- Entire occlusion must be reestablished, including changes in the occlusal vertical dimension.
- Class II division 2 and Class III molar and jaw relationships are seen.

Residual Ridge Characteristics

- Ideally or minimally compromised
- The residual bone height of 21 mm measured at the least vertical height of the mandible on a panoramic radiograph
- Residual ridge morphology resistant to horizontal and vertical movement of the denture base, type A maxilla
- Location of muscle attachments conducive to denture base stability and retention, type A or B mandible
- Moderately compromised
- Residual bone height of 16–20 mm measured at the least vertical height of the mandible on a panoramic radiograph
- Residual ridge morphology resistant to horizontal and vertical movement of the denture base; type A or B maxilla
- Location of muscle attachments with limited influence on denture base stability and retention, type A or B mandible
- Substantially compromised
- Residual alveolar bone height of 11–15 mm measured at the least vertical height of the mandible on a panoramic radiograph
- Residual ridge morphology with minimum influence to resist horizontal or vertical movement of the denture base, type C maxilla
- Location of muscle attachments with moderate influence on denture base stability and retention, type C mandible
- Severely compromised
- Residual vertical bone height of 10 mm measured at the least vertical height of the mandible on a panoramic radiograph
- Class I, II, or III maxillomandibular relationships

- Residual ridge offering no resistance to horizontal or vertical movement, type D maxilla
- Muscle attachment location that can be expected to have significant influence on denture base stability and retention, type D or E mandible

This guideline is very helpful to decide for an FPD, an RPD, or the combination of both. Naturally, Ante laws, root shape, and angulations of abutment teeth can also be utilized in making this decision. As a rule, an RPD is then indicated when the following circumstances are there.

RPD Indications

- In the absence of distal abutment tooth. The question is which tooth in the posterior region is sufficient for an FPD and in which situation should we make an RPD? To answer this question, we should discuss here the "shortened dental arch theory."

Shortened Dental Arch Concept

The shortened dental arch (SDA) concept was first introduced by Arnd Käyser in 1981. Despite the SDA concept taking a long time to gain acceptance among traditionalists, today's dental literature agrees that the SDA concept should be considered as an alternative to any prosthetic treatment in partially edentulous arches. Käyser proposed that the four occlusal units/pairs, preferably in a symmetrical position, are sufficient to the functioning of the dentition (Fig. 5.5a, b).

The World Health Organization recommends that a functional, esthetic, natural dentition consists of at least 20 teeth (10 pairs of antagonistic or functional units/as from premolars to premolars). Likewise, the dental literature indicates that dental arches, including the anterior and premolar regions (premolar arch), meet the requirements of a functional dentition. It has also been shown that SDAs having 3–4 posterior occluding pairs can last for 27 years or more.

There have been many studies evaluating the SDA concept in terms of different factors such as temporomandibular disorders (TMD), chewing ability, occlusal stability, oral function and comfort, periodontal problems, and quality of life. The results obtained from the studies are summarized below:

Fig. 5.5 (**a**) Shortened dental arch in maximum intercuspal position (MIP). (**b**) Shortened dental arch. Occlusal view of the maxillary arch

1. In cases having 0–2 pairs of occluding premolars (extreme SDA), occlusal instability may occur. On the other hand, in cases having 3–4 pairs of occluding premolars, no evidence has been found that occlusal instability occurs. Clinically insignificant migration may occur. When compared to full dentition, more interdental gaps between the premolars and anterior teeth contact and less alveolar bone support have been observed in SDA cases having 3–5 occluding pairs. However, it has been shown that the all parameters remained stable in the long-term period.
2. Premolar arches and at least one occluding pair of molars provide satisfactory masticatory efficiency. Only extreme SDA cases present severely reduced chewing ability.

3. It has been observed that the lack of molar support did not cause TMD. However, when all premolar and molar teeth were unilaterally or bilaterally lost, the risk of pain and joint sounds seemed to increase. There is no evidence that replacement of molars with an RPD is superior when compared to SDA regarding TMD pain over the 5-year period. Sufficient mandibular stability can be provided by the presence of bilateral premolar support.
4. It has been shown that the SDA cases with or without RPDs in the mandible had more mobile teeth and lower alveolar bone scores compared to full dentition cases. However, when evaluating the results of the study, the need to consider that the SDA patients are also in a high-risk group in terms of periodontal problems leading to tooth loss has been emphasized.
5. In cases having three to five occluding pairs, it has been shown that the oral function and comfort were not evidently enhanced by a free-end RPD. It has been also revealed that survival of premolars was higher in full dentitions when compared to SDAs, but in SDA cases no difference has been found between those with or without an RPD. Therefore, it has been recommended that patients having SDA have to be evaluated in high-risk groups, and special care should be given to avoid further tooth loss. Additionally, in a multicenter study, it has been shown that there were no differences regarding tooth loss over a 5-year period between patients treated with precision attachment-retained RPDs and according to the SDA concept, conserving or restoring a premolar arch with cantilever-fixed prosthesis. It has been concluded that the SDA patient's opinion will become more important when choosing the fixed or removable restorations. In addition, replacement of the molar teeth with a free-end RPD has not been recommended.
6. No significant differences have been found between the SDA patients and the patients treated with precision attachment-retained RPDs regarding oral health-related quality of life. It can be concluded that replacing molar teeth with an RPD does not provide any contribution to oral health-related quality of life in SDAs.

While the anterior teeth and premolars can together compensate for the function (such as biting, chewing, speech, esthetics, temporomandibular joint, and dental arch stability) of the molars, the molars cannot compensate for the function of the anteriors and premolars. Thus, it clearly emerges that anterior teeth and premolars are indispensable for the stomatognathic system. From this perspective, prosthetic dentistry has been focused on the patient's subjective oral functional needs and has emphasized that the following "physiological or healthy occlusion principles" should be considered essential: (1) absence of pathologic symptoms and signs; (2) presence of satisfactory function, esthetics, and comfort; (3) existence of mandibular stability and variability in form and function of the stomatognathic system; and (4) presence of adaptive capacity of the stomatognathic system to changing situations.

If a patient having premolar dental arch is satisfied with his/her esthetic appearance, masticatory function, psychosocial comfort, and other functionalities including phonetics, tactile perception, taste without feeling pain, and restoration of missing molars are not necessary. In fact, a treatment approach which insists on restoring all missing teeth has been called as "28-tooth syndrome" and "overtreatment" in dental literature.

In SDAs, it is not recommended to extract healthy non-opposed posterior teeth due to their esthetic and functional contribution to the stomatognathic system. Thus, alveolar bone loss can also be prevented, and possible abutment can be preserved.

In SDA concept, it is important to remember that some contraindications exist, such as severe Class III and Class II malocclusions, indication of parafunction, anterior open occlusal relationship, noticeable alveolar bone loss, excessive tooth wear, and preexisting TMD.

The presence of periodontal diseases, caries, and occlusal instability should be carefully evaluated in SDAs. Such SDAs or dentitions are considered "complicated impaired dentitions." After eliminating complication factors, prosthetic treatment can be an alternative, or patients should be monitored more frequently.

It has been emphasized that extending the SDAs by a cantilever-fixed prosthesis, RPDs, or implant-assisted prostheses may lead to a positive outcome in the presence of the following factors: chewing difficulties, esthetic problems, patient's preference for restoration, and extreme and asymmetric SDAs. It has also been shown that replacing the first molar with implant-assisted prosthesis improved the bite force and masticatory efficiency in SDAs. This option can also be an alternative treatment to preserve alveolar bone resorption.

- Where resistance to a lateral movement is needed from contralateral teeth and soft tissues (cross-arch stabilization)
- When there is a considerable bone loss in the visible anterior region

It is well known that multiple edentulous gaps mostly are best restored with a combination of FPDs and RPDs. However, all this information is still not sufficient to decide where a confusing question remains unanswered: Which edentulous gap should be restored with an FPD and which gap should be left as a modification for an RPD in combined planned prosthetic therapy? The rules for making this decision can be summarized as follows:

- If possible, anterior edentulous spaces should be restored with FPDs.
- In cases of missing canine tooth together with 2 or more adjacent teeth, it is impossible to restore this gap with an FPD.
- A single premolar tooth is a weak abutment for an RPD. The clinician should seek alternatives to include this tooth into the FPD. For example, the gap between the second premolar and canine tooth (maxillary or mandibular) should best be restored with an FPD.
- In Kennedy Class II cases with contralateral modification spaces, at least one modification space should be left for the purpose of bilateral stabilization. If not, the situation is changed to a pure Kennedy Class II case which has well-documented prosthodontic difficulties (Fig. 5.6a–e).

5.2.3.5 Using the Diagnostic Casts for Pretreatment

Indications of Occlusal Equilibration

- The patient has a temporomandibular disorder (TMD) and occlusal problems (always after occlusal splint therapy).
- The patient has no TMD, but only occlusal problems, and the occlusion needs to be reestablished by constructing extensive restorations.

The occlusal problems in which occlusal equilibration is indicated are mostly:

- A prominent (bigger than 2.5 mm) and/or with a lateral component (asymmetric slide in centric) (Pullinger-Seligman) discrepancy between retruded contact position (RCP) and maximum intercuspal position (MIP) (Fig. 5.7a–d).
- The lack of anterior or canine guidance without a prominent attrition in incisors and/or canine teeth. The premature occlusal contacts in eccentric movements of the mandible are mostly a result of supra-erupted or tilted molar teeth. In such cases, the most frequently seen occlusal problem is a premature nonworking side occlusal contact in the second or third molar teeth, the premature contact between mandibular third molar and maxillary second molar teeth during protrusive movement being the second.

The Rules of Occlusal Equilibration

- The patient should be aware of the treatment procedures and should have no objections. Patients with psychosomatic disorders are not good candidates for occlusal treatments.
- The procedure should be tested in mounted casts before applying any treatment to the mouth of the patient.
- An occlusal adjustment diagram should be finished before grinding the teeth.

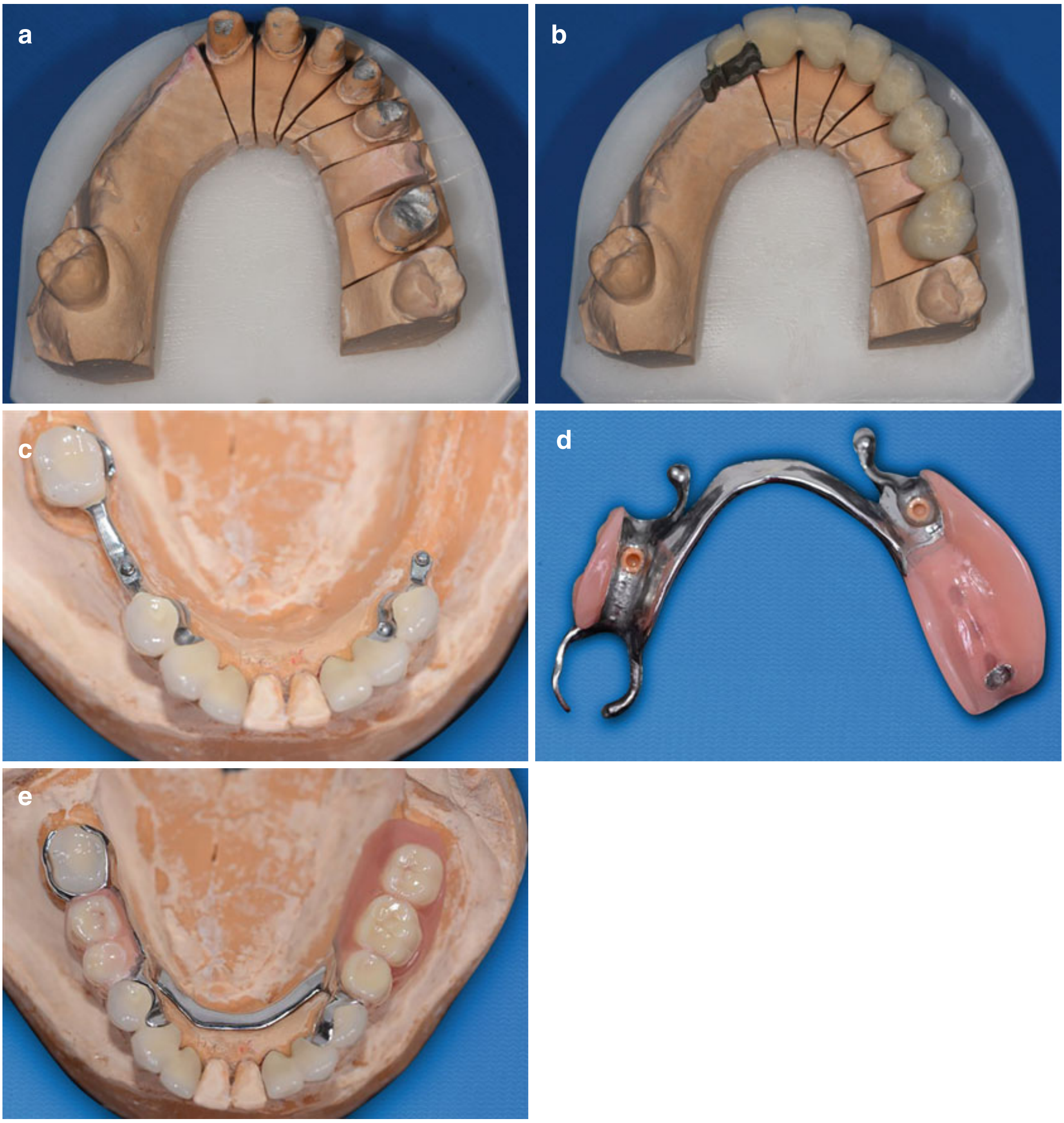

Fig. 5.6 (**a**) A Kennedy Class III Modification 1. (**b**) A wrong treatment planning of the case. The smaller edentulous gap should be left as a modification space for cross-arch stabilization. (**c**) A Kennedy Class II Modification 1. In this case the treatment planning is logical. The edentulous gap is splinted with a bar attachment. (**d**) The removable partial denture (RPD). Mucosal view. (**e**) The removable partial denture (RPD). Occlusal view

- The adjustments on the mounted casts should be done by the clinician himself/herself maximum 30 min before the treatment in the mouth of the patient, for the hand memory of the clinician.
- Given the choice, the restorative material should be chosen against a natural tooth surface.
- The centric premature contacts should be adjusted first, followed by working side contacts, protrusive contacts, and nonworking side contacts.
- The centric premature contact should be grinded from the fossa, not from the cusp.
- Once the centric adjustment is finished, the centric stops should be preserved during the eccentric adjustments.
- Ideally occlusal adjustments shouldnot exceed the enamel boundaries.

Fig. 5.7 A patient with extremely long slide in centric. (**a**) Retruded contact position (RCP). (**b**) Maximum intercuspal position (MIP). (**c**) Retruded contact position (RCP) in articulator. (**d**) The occlusal adjustment is prepared on study models. Yet maximum occlusal contacts are created in both mandibular positions

- For the occlusal adjustments to be precisely and securely made, proper instruments should be selected to generate a smooth surface texture while not overheating the teeth. After the grinding and polishing procedures, fluoride application over the teeth is recommended.

MIP-RCP Adjustments

Regardless of which centric record has been preferred for the prosthodontic restoration, the important point is to achieve a smooth and symmetrical slide between MIP and RCP. A slight decrease in occlusal vertical dimension (about 1 mm) from RCP to MIP is acceptable. These dynamic contacts should be prepared on each posterior tooth, although in nature these contacts only appear in the first premolar or second molar teeth. If it is possible, the adjustment should be applied only on central or marginal grooves. In cases that the cusp needs also to be grinded, it is important to avoid touching the tips of the supporting cusps. Premature contacts are marked and removed with a sharp blade continuously until a slightly curved platform is created at the depth of the occlusal fossa in order to supply a centric stop for the opposing supporting cusp. It is important to note that the articulator's incisal pin is always in contact with the curved (10–15 grad) incisal table during the small movement between MIP and RCP. An articulating paper with 20–60 μm will serve the purpose. The clinician should be careful not to grind down or break the cusps of the gypsum model. For hardening the gypsum it is advisable to apply a proper solution on the occlusal surface of the cast.

Eccentric Adjustments

In a natural dentition for the eccentric occlusion, almost always canine guidance is chosen. Accordingly, following the centric adjustments, the working side contacts are analyzed in the articulator. The upper buccal and lower lingual cusps should be eliminated. In cases in which canine guidance is impossible to attain, group function occlusion is the next preferred option. The nonworking side contacts are undesirable and should be adjusted accordingly. The main problem of equilibrating this kind of premature contacts is the risk of destroying the harmony of the centric stops. In a normal occlusion, the mediotrusive contacts are established between the upper palatal and lower buccal cusps, collectively named supporting cusps. Thus, by eliminating these contacts, clinicians might easily grind the centric stops. If this happens, in order to reestablish the centric occlusion, the occluding antagonist fossa should be restored.

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6 Preparation of the Mouth for Removable Partial Dentures

Hakan Bilhan

The long-term prognosis of removable partial dentures should rely on optimal tissue and tooth support. A good technical work is not the only factor bringing clinical success. Denture-bearing areas, abutment teeth, and all surrounding tissues should be adequately prepared before any impression for initialization of denture fabrication is attempted. A reliable preprosthetic preparation will not only guarantee a more comfortable patient use, but also a better esthetic result. Preprosthetic interventions generally need a multidisciplinary approach, since a couple of the treatment methods belong in the scope of specialized dental fields and be better exercised by experienced hands. Preprosthetic oral surgery and periodontal and orthodontic preparations do not belong to a daily clinical practice of a dental professional. The different treatment modalities to be considered are presented and explained briefly in this chapter. It should be remembered that these interventions classified as periodontal, oral surgical, soft tissue conditioning, and orthodontic preparations will assure a long-term success for the planned prosthesis.

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6.1 The Importance of Preprosthetic Preparations

The preparation of the mouth plays a key role in the long-term success and patient satisfaction of a removable partial denture (RPD). Preprosthetic procedures involve methods for preparation or improvement of patients' ability to wear removable dentures. Most procedures are centered around soft or hard tissue corrections to allow prosthetic devices to fit more securely and function more comfortably. However, dental arrangements are indispensable, too. In addition to crown and bridge work (see Chap. 7), periodontal, endodontic, restorative, and orthodontic preparations are important in long-term success of an RPD. For evaluating whether a tooth should be kept or extracted, factors such as the mobility, condition of the crown, the endodontic status, and radiographic assessment play a key role. A good root canal treatment is vital, especially if the tooth will be used as an abutment. If an existing root canal filling seems unreliable, a retreatment should be considered. In the same manner, decayed or damaged teeth should be restored before the prosthetic treatment is initiated.

Forty years ago, in the era when dental implants were not a rescuer yet, bony augmentation was incorporated in severe cases and included very invasive procedures such as cartilage grafts, rib grafts, alloplastic augmentation, visor osteotomies as well as sandwich grafts. Patients who had

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been considered poor candidates for that kind of extensive surgery were often left with less satisfactory results both functionally and esthetically. The goal of preprosthetic surgery in this century is to establish a functional biologic platform that will support prosthetic restoration without contributing to further bone or tissue loss. In this manner, it will be possible to achieve a denture that restores function, is stable and retentive, preserves the associated structures, and satisfies esthetics.

The supporting hard, soft, and dental tissues must be in excellent form to be able to provide a problem-free adaptation and usage period. The procedures should commence with a detailed anamnesis followed by a proper examination. The anamnesis consists of information about dental and medical history giving the clinician a global view of the patient. During the oral examination, soft and hard tissues likewise the remaining dentition are inspected. The color, thickness, consistency, and surface of the mucosa should be healthy. The bony base should provide solid, but smooth support. The status of the teeth will be a substantial hint for the planning of the denture. Missing teeth; angulated, rotated, or inclined teeth; teeth needing additional restorative procedures; and teeth being candidates for extraction should be jot down. A radiographic evaluation is vital in the prosthetic planning of any kind of prosthesis. On radiographs, impacted teeth, hidden chronic infections, cysts, residual roots, and real bony (periodontal) support of abutment teeth are visible. Study casts are an efficacious way to evaluate patients' oral condition and propose subsequent treatment such as extractions, orthodontics, or design of tooth restorations. By the assessment of the casts mounted to the articulator, details from jaw relation to interarch distance may be visualized. On the other hand, the casts should be surveyed in order to determine the path of insertion and tissues interfering. This approach will ease detection of many preprosthetic intervention needs and help with the treatment planning. The oral preparation principles will be explained here by following order:

1. Periodontal preparations
2. Oral surgical interventions
   - Preparation of the bony base
   - Soft tissue interventions
   - Removal of teeth or tooth remnants
3. Preprosthetic soft tissue conditioning procedures
4. Orthodontic preparation

The purpose of these procedures is to attain an oral status with optimum health and to eliminate any unfavorable condition. The initial prosthetic treatment, consisting of tooth preparation as well as the adaptation or modification of an interim prosthesis, should follow the other preparation steps listed above. Being faithful to the philosophy of this book, the prosthetic arrangement should be the last step and is subject of the next chapter. In this manner, the impression procedures will follow the accomplished mouth preparation. Surgical and periodontal preparation should be completed in a certain time interval in advance, if at all possible, at least 6 weeks and preferably 3–6 months, allowing the necessary healing period before abutment tooth preparation.

6.2 Periodontal Preparation

It is meanwhile well known that RPDs may favor plaque accumulation and it is of great importance to maintain or obtain healthy periodontal tissues before any prosthodontic approach is attempted. It is clinically vital to ensure an established periodontal health condition for a long-term successful RPD treatment. Patients should receive detailed instruction on oral hygiene procedures in order to keep plaque around abutment teeth and RPD components to a minimum. Periodontal preparation, however, not only includes debridement, curettage, or attainment of oral hygiene, but also various surgical interventions. Crown lengthening procedures in order to obtain better pink esthetics or a biomechanically more stable crown height in some instances may be a very valuable treatment choice. On the contrary, from time to time lateral or coronal sliding flaps can be necessary in order to cover recessions.

Elimination of extreme occlusal interferences is essential in order to avoid overloading any teeth in the arch. Depending on the strength of the early contact and position of the related tooth, elimination measures from simple grinding to tooth extraction may be considered. Teeth with slight to moderate mobility should be judged for splinting either by wire (same way as the orthodontic retainer) or by fixed prostheses. If there are several teeth of that kind, an intraoral appliance is recommended. By the use of an intraoral appliance, occlusal forces are more evenly distributed and the probability of occlusal trauma on each tooth is reduced.

The introduction of dental implants has changed the look at periodontal efforts in partially edentulous patients drastically. The attempt to keep teeth with an indefinite prognosis is rather considered risky, and instead of doing complicated and uncomfortable procedures or inductive osseous surgery, teeth are rather extracted. Interventions such as furcation involvement, guided tissue regeneration, or flap operation may endanger the long-term success of the planned denture by a possible unplanned early tooth loss. If it is an abutment candidate, the extraction of a compromised tooth should always be regarded as an option, since it is known that teeth provided with clasps should have at least 70 % of bony support. In periodontally compromised patients, the recall sessions should be scheduled more frequently and those patients are clinically checked at least every 3 months.

6.3 Oral Surgical Interventions

6.3.1 Preparation of the Bony Base

It may be necessary to intervene surgically before RPD construction in several situations. As a general principle, in all bony interventions, a full mucoperiosteal flap is reflected to expose all the bony area. Vertical releasing incisions may be necessary if adequate exposure cannot be obtained since trauma of the soft tissue flap may

Fig. 6.1 Bony prominences or spikes that could cause ulcerations or sore spots under the denture base or even complicate the path of insertion

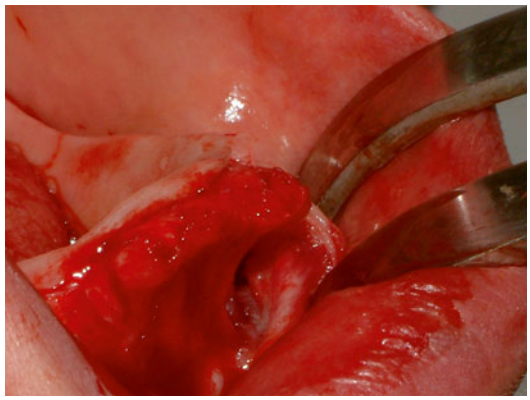

Fig. 6.2 A simple surgical procedure could help obtaining a smooth mucosal surface for denture base support

occur. Recontouring of bone may require the use of a rotary instrument in large areas or a hand file in smaller areas. Once bony correction is complete and visualization confirms that no irregularities or undercuts exist, surgery may be finished.

Bony prominences or spikes (Fig. 6.1) that could cause ulcerations or sore spots under the denture base should be smoothed (Fig. 6.2). Too prominent bony undercuts could create difficulties in the establishment of the path of placement of the planned denture and should be eliminated before by an alveoloplasty. An easy bidigital pressure may prevent most of alveoloplasties after tooth extraction (Fig. 6.3), which is the simplest alveoloplasty procedure. However, overcompression and overreduction of irregularities should be

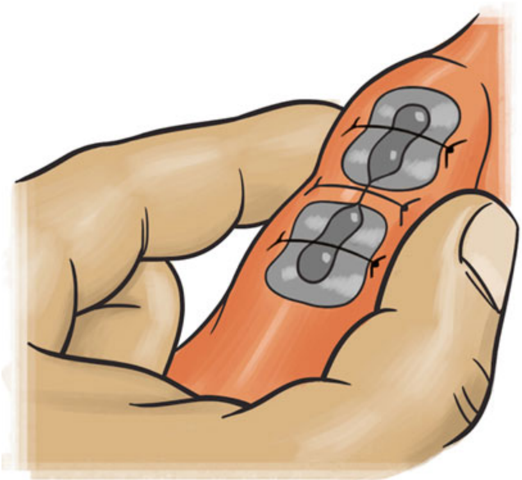

Fig. 6.3 An easy bidigital pressure after tooth extraction, which could be considered as the simplest alveoloplasty procedure, may prevent most of alveoloplasties

Fig. 6.4 An exostosis or a torus on the lingual side of mandibular premolars

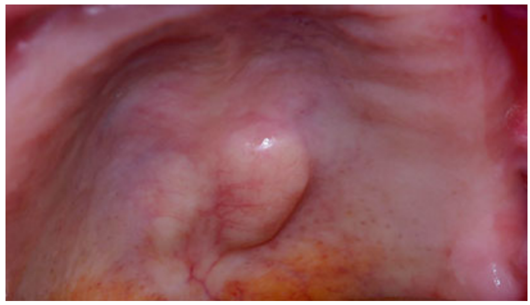

Fig. 6.5 Palatal torus is found in the midline of the maxilla and may be a great obstacle for denture seating

avoided. The only exception for the need of bidigital pressure after tooth extraction would be a planned future implantation at the same site, since it could reduce the necessary bucco-lingual width of the alveolar crest. If there are several irregularities, these may cause undercuts hindering the path of insertion for RPDs. This kind of bony prominences need more complex alveoloplasties, and in many cases the elevation of mucoperiosteal flaps using a crestal incision with vertical releases is necessary to prevent tears and to produce the best access to the alveolar ridge, thus increased pain and discomfort for the patient and a longer healing period before prosthetic restoration can proceed may be expected.

An exostosis or a torus is found either on the lingual side of mandibular premolars (Fig. 6.4) or on the palatal midline (Fig. 6.5). In both cases, it is a hindrance for denture construction and should be resected surgically. The etiology is unknown and an incidence of up to 40 % in males and 20 % in females is reported. Tori may appear as a big single or multilocular bony mass either unilaterally or bilaterally. They are rarely removed if a patient is not a candidate for a removable denture. Nevertheless, they may be a significant bulk to insertion, interfering with the overall comfort, fit, and function of the planned prosthesis. As usual in bony interventions, rotary instrumentation with a round bur may be used for small areas, whereas the treatment of choice for large tori should be rather sectioning with a fissure bur. Once sectioned into several pieces, the torus is easily removed with a chisel. Care must be taken not to expose the floor of the nose. Final contouring may be done with an egg-shaped or a larger round bur or a hand file. The same principles are valid for mandibular tori. Small protuberances can be taken away with a mallet and chisel. Large tori should be divided superiorly from the adjacent bone with a fissure bur parallel to the medial axis of the mandible and treated as in small protuberances with a mallet and chisel. It is not important that the bony protuberance is totally removed, if the goals of the procedure are achieved.

Excesses in the maxillary tuberosity, also named tuberostosis, may consist of soft tissue, bone, or both. Sounding with a needle or a panoramic radiography can help differentiating between the tissues. However, the most certain way to identify bony irregularities is to visualize

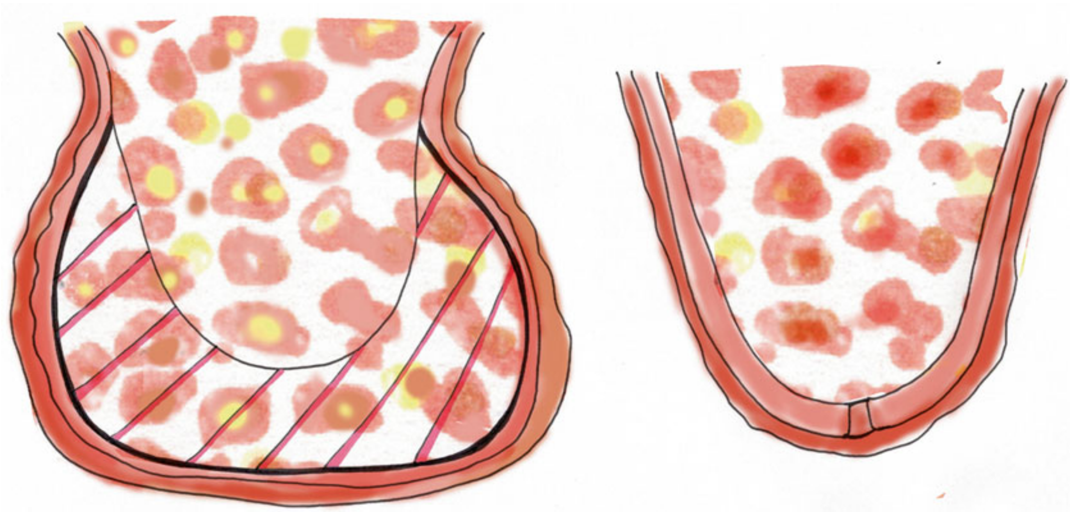

Fig. 6.6 A tuberostosis occupies bucco-lingually too much space and should be reduced

during surgery when the mucoperiosteal flap is raised. Radiography before the operation is more suitable for ascertainment of anatomical limitations such as the maxillary sinuses. Excesses in the area of the maxillary tuberosity may encroach on the interarch space and decrease the overall freeway space needed for proper prosthetic function. It is of great value that the necessary interarch distance is regained before denture planning. Additionally, a tuberostosis occupies bucco-lingually too much space, as well (Fig. 6.6). In many cases, this may create a bilateral undercut situation being an obstacle for a decent path of denture insertion. The level of the maxillary sinus should be carefully evaluated before any bony intervention is attempted in the area of the tuberosity. Although small sinus perforations are generally reported to require no treatment as long as the membrane remains intact and only large perforations must be treated with a tension-free tight closure, it is advisable to keep a greater distance to the sinus in order to avoid later complications. The overlying soft tissue may be removed in a wedge-shaped fashion in order to reduce the overall soft tissue bulk overlying the bony tuberosity. Excess overlying soft tissue may be trimmed in an elliptic fashion from edges of the crestal incision to allow a tension-free passive closure. Genioglossus and mylohyoid muscle attachments can interfere with stability and function of conventional mandibular prostheses from time to time and should be relieved. In cases of mandibular atrophy, especially, the mylohyoid muscle contributes significantly to the displacement of conventional dentures. Compared to a few decades ago, there are fewer indications for the reduction of the mylohyoid ridge, especially with the availability of dental implants. Nevertheless, in severe cases of mandibular atrophy, the external oblique and mylohyoid ridges may be a significant source of discomfort as the overlying mucosa is thin and easily irritated by denture flanges. This book is designed to give clinicians recommendations for daily practice. Some of these procedures are rarely indicated and need a serious surgical background. There are additionally some other titles being part of the preprosthetic surgery list, such as “Treatment of Skeletal and Alveolar Ridge Discrepancies,” “Alveolar Distraction Osteogenesis,” or “Mandibular Augmentation.” However, these treatment modalities are severe surgical interventions, needing oral and maxillofacial surgery cooperation in a multidisciplinary approach.

6.3.2 Soft Tissue Interventions

With the eventual bony remodeling following tooth loss, muscle and frenulum attachments initially not being in a problematic position, can start to create complications in prosthetic reconstruction and to pose increasingly problems with regard to prosthetic comfort, stability, and fit. From time to time, these attachments should be altered before removable dentures can be attempted. Inflammatory fibrous hyperplasia of the vestibule, called epulis fissuratum, and inflammatory hyperplasia of the palate should be addressed before any type of prosthetic reconstruction can proceed. Frenulum attachments consist of thin bands of fibrous tissue covered with mucosa extending from the lip, cheek, or floor of the mouth to the alveolar periosteum. The height of this attachment varies from individual to individual. Although in dentates, frenulum attachments rarely cause a problem, in individuals using removable dentures they may interfere with fit, stability, and retention of the prostheses. A pronounced frenulum can additionally weaken the denture and cause fractures. Several surgical methods have been introduced for the excision of these attachments. While simple excision and Z-plasty are effective for narrow frenulum attachments, a vestibuloplasty is often indicated for frenulum attachments with a wide base. Although vestibular frenectomies are less associated with complications, careful attention is advised to Wharton's ducts and superficial blood vessels in the floor of the mouth and ventral tongue for lingual frenectomy interventions. The severity of the frenulum interaction may be identified by eversion of the lip or cheek or by tongue movement.

Hyperplastic soft tissues such as epulis fissuratum or fibrous ridge (flabby ridge) or fibromae caused by chronic trauma are subject to soft tissue surgery before any prosthodontic planning can be accomplished. In general, a 3- to 4-week period to allow for soft tissue remodeling is adequate before impressions for prosthesis fabrication may be taken. Fibrous inflammatory hyperplasia is often the result of ill-fitting dentures producing inflammation of the underlying mucosa and eventual fibrous proliferation. The adjustment of the offending denture flange with an associated soft reline of the prosthesis is mostly an insufficient measure. Most of the time, a surgical excision is necessary and some sources even suggest laser ablation, too.

Vestibuloplasty operations that are ridge extension procedures in the maxilla and mandible, once having been very important in obtaining better vertical height of the alveolar ridge, have lost their significance after the introduction of dental implants. However, in combination with removable dentures, the importance of a safe distance without mobile soft tissue, from alveolar crest to sulcus, is not neglectable. In cases where the sulcus depth is lost, vestibuloplasty operations can be necessary. In some situations, even free connective tissue grafts and/or free gingival grafts may be necessary. The use of rearranged dentures with elongated denture flanges after vestibuloplasty operations is vital in order to reduce the shrinkage and keep the tissues and regained sulcus depth in place. If there is no existing denture, a preoperatively prepared plate may be used. The plate can be used with or without tissue conditioners. However, it is advisable to fixate the plate in order to assist a healthy healing of the wound. If retention cannot be maintained conventionally with the tissue conditioner or even additional denture adhesives, even screw fixation should be considered.

6.3.3 Removal of Teeth or Tooth Remnants

Prior to RPD production, retained roots or impacted teeth should be surgically removed, especially when they are located very superficial in edentulous parts. Any pathology associated with teeth or dental remnants are to be extracted. The only exception for the necessity of root remnant removal would be a strategic position, such as the canine, in a patient not operable due to systemic condition, where the root may serve to delay alveolar atrophy and keep the crestal height. In systemically or financially compromised patients, where the use of dental implants cannot be considered, a decently root canal treated tooth remainder can be useful. Keeping the root with a root cap can be helpful in maintaining the bone height and if the root is strong enough, an attachment retained in the root could help to increase patient comfort, thus patient compliance. A tooth occupying a strategically false position may be considered as candidate for extraction, even if it is free of decay and periodontally healthy, if an orthodontic treatment is not a choice. In this chapter, interventions such as apicectomies, bi- or hemisections are not appreciated for abutment teeth, since surgical weakening of abutment teeth may mislead the readers.

6.4 Preprosthetic Soft Tissue Conditioning Procedures

From time to time, patients, who are candidates for a new denture, need conditioning of supporting tissues in edentulous areas before the final impression phase of treatment begins. An inflammation or irritation of the mucosa at denture-bearing sites (Fig. 6.7) or distortion of normal anatomic structures, such as incisive papillae, rugae, and retromolar pads make a pretreatment inevitable. If a systemic disease or bruxism is not the etiology, in general, ill-fitting or poorly occluding removable dentures are the causative factor for these conditions. The allergic stomatitis as a differential diagnosis must be kept in mind at all times. Early stages are easily treated by an improvement of hygiene practices. In case of denture-related stomatitis, a well-defined home care program should implement the denture and tissue conditioning. The brushing of the palate and the dorsum of the tongue should be meticulously explained and ordered to the patients, since it strictly belongs to the hygiene program. Tissue conditioning materials are elastopolymers that continue to flow for an extended period, permitting in amounts sufficient to provide a cushioning effect to distorted tissues, thus to recover, probably through more evenly distributed occlusal forces. The tissue conditioner is more beneficial when deflective or interfering occlusal contacts of old dentures are eliminated or the denture base is extended to enhance support, retention, and stability. The conditioning period should be long enough to allow tissues to recover. Although generally change of the provisional relining material in 4–7-day intervals is considered clinically acceptable, the authors of this book recommend a maximal 3-day interval for a faster relief. Most of the time, the clinician will notice a dramatic change within a few visits. In resistant situations where no improvement in irritated and inflamed tissues is seen, a consultation from a physician would be advisable. Differential diagnosis would include a *Candida*-induced denture stomatitis, where drug administration following microbiological analysis is indispensable. In case of an inflammatory papillary hyperplasia, which is also called Newton III after Newton's classification, the latest stage of an untreated denture stomatitis, the lesion appears as multiple proliferative nodules underlying a mandibular prosthesis likely colonized with *Candida*, mainly *Candida albicans*. In addition to systemic drugs, soaking of the prosthesis in a very dilute sodium hypochlorite solution helps in decreasing the overall colonization of the prosthesis. However, the risk of initializing an undesired corrosion in alloy parts could be considered as a disadvantage of this intervention. Additionally the oral disinfection with a chlorhexidine rinse is advisable. It must be addressed that in comparison to lesions such as the epulis fissuratum, inflammatory papillary hyperplasia reacts in a positive way to denture adaptation and tissue conditioning. In proliferative and persistent cases necessitating surgical treatment, excision should be the method of choice. Many

Fig. 6.7 Sight of inflamed mucosa at denture-bearing sites

methods including sharp excision with a scalpel, rotary debridement, loop electrocautery as described by Guernsey, and laser ablation with a carbon dioxide laser are acceptable. Treatment precedes supraperiosteally to prevent exposure of the underlying palatal bone. Subsequently, the use of a tissue conditioner is helpful to minimize patient discomfort and stabilize the end result. Although very often patients do not comply, a good way for tissue conditioning could be to let the tissues rest. If the patient agrees, the best way for tissue healing is to quit wearing the dentures for a certain time. Systemic drug administration is inevitable if a microbiological smear test gives a positive result. On searching the latest articles about treatment of oral candidiasis, it could be concluded that although nystatin and amphotericin B can be classified as the drugs most often used locally, fluconazole oral suspension has been proven to be a very effective drug. Owing to its good antifungal properties, its high patient acceptance, and its efficacy compared with other antifungal drugs, fluconazole was found to be the worldwide drug of choice as a systemic treatment of oral candidiasis. In cases with *Candida* strains resistant to fluconazole, other drugs like itraconazole or ketoconazole may be considered as alternatives.

6.5 Orthodontic Preparation

There are generally two different indications for preprosthetic orthodontic preparations. Either the neighboring teeth are mesialized or distalized into the gap, or an unsupported tooth from the opposing jaw may have elongated into the space, where a tooth was lost earlier. The orthodontic treatment has the goal to reposition this kind of teeth (Fig. 6.8) in order to improve the path of entrance and avoid future food trapping undercuts. Another helpful orthodontic intervention is the preparation of the edentulous gap for exact mesio-distal width. Mainly for esthetic reasons, it is important that the gap of missing teeth overlaps the teeth to be setup in the denture. Mostly, a mesialization or distalization of neighboring teeth can be a compulsive measure to enhance esthetics.

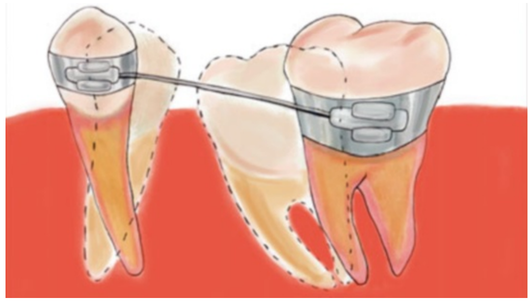

Fig. 6.8 Neighboring teeth which are mesialized or distalized into the gap where a tooth was lost earlier may be orthodontically repositioned, in order to improve the path of entrance and avoid future food trapping undercuts

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7 Preparation of Abutment Teeth

Muzaffer Ateş

The principle of "protection of healthy remaining tissues" that is one of the basic rules of preparing a removable partial denture (RPD) is occasionally ignored. This situation causes various problems, especially on abutment teeth in RPD wearers. Due to these problems, abutment teeth loss occurs and, hence, additional treatments need to be performed on prosthesis. To avoid such probable problems, for an RPD wearer patient, primarily a diagnostic cast model should be formed and treatment plan should be carefully performed on this model. Following surgical, periodontal, and endodontic treatments, the model should be placed into a surveyor to examine the guide surfaces and to determine which teeth will be used as abutment teeth. In order to ensure parallelism, the teeth which require grinding, and the teeth which will be crowned, should be determined. The order and scheme of these treatments and necessary precautions required to be taken for crowned teeth are discussed below.

One of the important steps of the mouth preparation is the preparation of the abutment teeth. Before starting preparations, the dentist should make sure that the other stages of the mouth preparation are completed. Usually, tooth decay and periodontal destruction on the abutment teeth of RPD wearers are observed. However, studies show that a well-planned removable denture does not cause any damage on the abutment teeth and the periodontal tissues. Actually, the space between the denture and the supporting teeth is a favorable place for food retention. Therefore, dentists claim that the patients are also responsible for tooth loss, since they do not pay enough attention to their oral hygiene. Although this claim is true for most cases, is the dentist not responsible for not taking necessary precautions?

In order to decide for the preparation of the supporting teeth, a diagnostic cast should be first prepared. After determining the vertical dimension of occlusion and centric relation, the diagnostic models are attached to the articulator using the split cast (Fig. 7.1). Then the model is studied on the surveyor to determine which teeth could be used as abutment and the preparations to be done.

These preparations can be performed in the following order:

1. Forming (creating) the guide planes
2. Preparation of rest's seat
3. Forming a retentive area
4. Crowning the abutment supporting tooth/teeth

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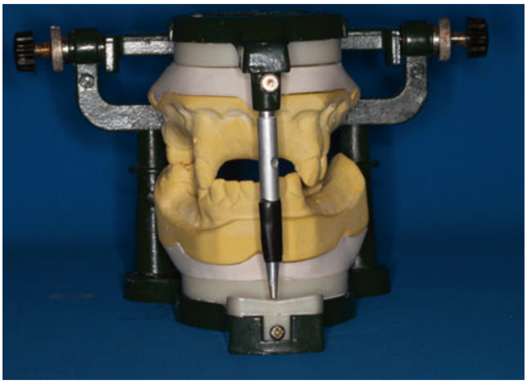

Fig. 7.1 Fixing of diagnosis models to articulator by split cast

The first three steps are completed on the supporting tooth/teeth.

These preparations should not go beyond the enamel borders. If performing of grinding is within the borders of the enamel, a crown restoration might not be necessary. Following the grinding, the tooth surfaces should be polished and afterwards topical fluoride should be applied. If the adjustments by grinding go beyond the enamel and penetrate dentine tissue, then crown restorations would be necessary.

7.1 Relationship of Guide Surface and Guide Plate

In RPD construction, an important concern is the tooth-mucosal joint area. When examined in RPD wearers, gingival recession and tooth decay is usually observed. When a tooth is extracted, there will be soft and hard tissue loss, but no change will be observed in the teeth adjacent to this soft tissue. As a result, an undercut area appears between the tooth and the soft tissues. When an RPD is constructed under these conditions, usually a space appears between the tooth and the prosthesis in the gingival zone. In such a case, the possible problems arising are (1) food accumulation in this area, (2) hypertrophy of the tissues to this space, (3) decrease in support of teeth, and (4) gingival recession due to food impaction.

In order to prevent these problems, metal framework should be adapted precisely to the interproximal surface of the abutment teeth. The part of the metal framework, which contacts the proximal surface of the supporting teeth, is called guide (proximal) plate, and the proximal surface of the supporting tooth is called the guide surface (plane).

The advantages of the accurate maintenance of the guide plate-guide surface relationship are as follows:

1. Food impaction is prevented.
2. Hypertrophy of the soft tissue between the tooth and the prosthesis is prevented.
3. The friction force in these areas supports the retention and stability of the prosthesis in great proportion.
4. Controlling of the movement of the teeth by supporting in antero-posterior direction.
5. The parts that are extended along the lingual/palatinal surfaces maintain reciprocation by compensating the pressure that the retentive arm applies while wearing and removing the prosthesis (Fig. 7.2).
6. A natural appearance is obtained by full contact of tooth and RPD without any space in between. Otherwise, the area between the teeth and the prosthesis will appear as a dark space, which will cause esthetic problems (Fig. 7.3).
7. Guide surfaces means making proximal surfaces of two or more supporting teeth parallel to each other and determining only one path of insertion for the RPD (Figs. 7.4 and 7.5).

By maintaining an accurate guide plate-guide surface relationship for all the abutment teeth, only one path of insertion for the prosthesis is designated. Otherwise, different paths of insertion will be formed and while the patient is wearing and removing the prosthesis, forces from multiple directions will be exerted on the abutment teeth with the clasps exceeding the elasticity (proportional limits) and resulting in an eventual deformation.

To maintain an accurate guide plate-guide plane relationship, the study model is examined on a surveyor, and the proximal surfaces that need to be grinded are determined by depending on the path of insertion. These

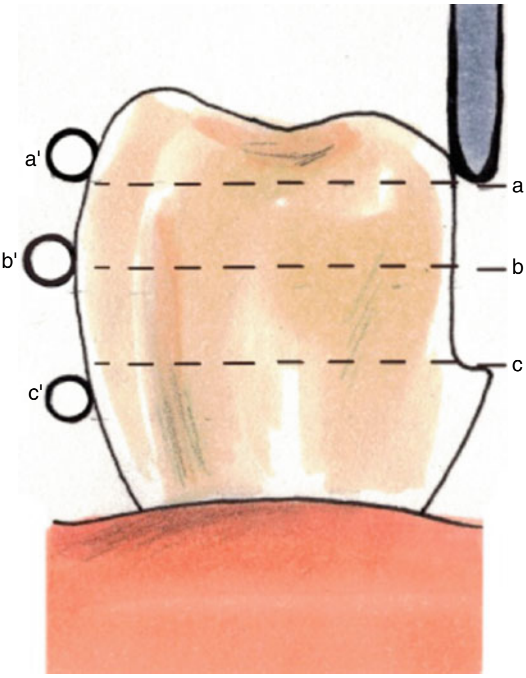

Fig. 7.2 To achieve the real reciprocation, reciprocal arm should contact *a* at the moment retentive arm contacts *a´* and reciprocation arm should contact point *c* while retentive arm is moving towards *c´*. Namely, the reciprocation arm should keep its contact to tooth during retentive arm's trace route from first contact to tooth until the end; thus, it should compensate particularly the pressure applied by the retentive arm while passing the survey line

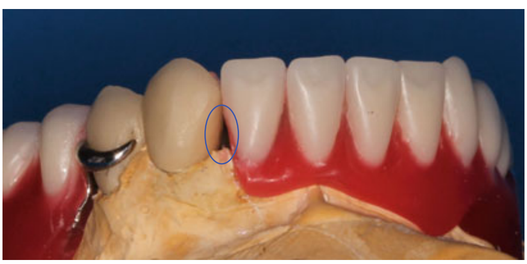

Fig. 7.3 The case that a gap (*stated oval shape*) remains between metal framework and supporting tooth

surfaces are marked with a red pen and necessary grinding is completed in the mouth according to these marks (Fig. 7.6). The grinding abrasions on the guide planes should not be plain and follow the teeth's curvature (Fig. 7.7). Guide planes should be prepared as 1.5–2 mm

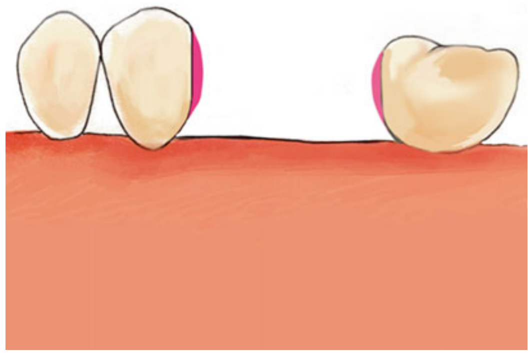

Fig. 7.4 Surfaces that are required to be abraded on guide planes (*marked as red*)

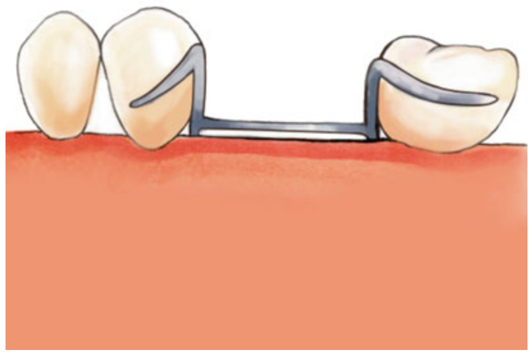

Fig. 7.5 Settled form of metal framework after abrasions is completed. In this way, guide plate and guide plane relationship and path of insertion of prosthesis (insertion/dislodgement) is determined

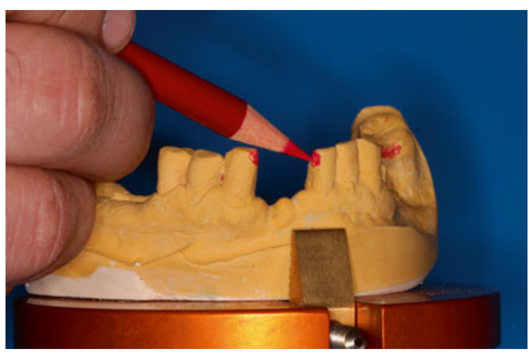

Fig. 7.6 Marking of the surfaces that should be abraded on study model

wide/height for the distal extension RPD and 2–4 mm height for the tooth supported RPD (Fig. 7.8).

7.2 Preparation of Rest Seats

After guide plate-guide plane relationship is maintained, rest seats should be prepared according to the rules mentioned in Chapter 10. As mentioned before, the rest seats should be prepared within the enamel borders and should be polished with various rubbers and fluoride should be applied then. If enamel borders are exceeded, inlay/onlay restorations may be helpful. In some cases, rest seats can be prepared on amalgam or composite resin. To obtain a sufficient sturdiness, the rests should have minimum thickness of 1 mm, and it should not cause occlusal interferences.

To comprehend if the rest seats have sufficient depth or not, it should be checked by making the patient bite a piece of baseplate wax. Silicone-based bite registration materials may also be used for this purpose (Fig. 7.9). Rests should never be replaced on inclined planes, such as the anterior teeth, when a rest is to be designed on a canine tooth, a cingulum rest should be prepared (Fig. 7.10). The fact that the lingual surfaces of the anterior teeth in the lower jaw is very plain in general, usually it is not possible to prepare rest seats without exceeding enamel borders. In this case, either tooth should be crowned and a cingulum rest seat should be prepared on crown or a cingulum rest seat should be formed with composite resin. If a cingulum rest is to be prepared with composite resin, the rest should be applied more than one tooth to ensure the distribution of the forces.

Fig. 7.7 The grinding abrasions on the guide planes should follow the teeth's curvature (*Green* is right)

7.2.1 Forming of the Retentive Area

In some cases, despite not having sufficient undercut on the abutment tooth, by little abrasions, a sufficient undercut area can be formed. However, because enamel is thin in the gingival third, it may be hard to prepare a retentive area without exceeding the enamel borders. In such cases, forming the undercut area with the composite resin material is possible (Fig. 7.11). If these methods are not sufficient, a crown restoration would be necessary. The height of contour can be quite high on some abutment teeth. The clasps on such teeth might be so close to the occlusal surface that they may cause occlusal interference. Because this situation will also cause deformation of the clasp and esthetic problems, this part of the tooth should be grinded to lower the height of contour towards gingivae.

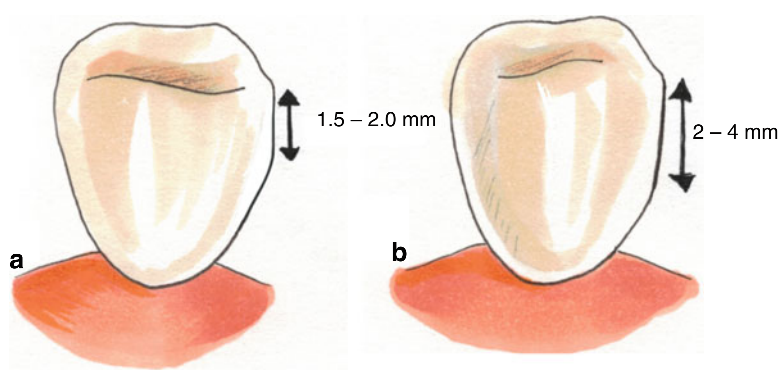

Fig. 7.8 (**a**) Abrasion proportion to be practiced on free-end prosthesis; (**b**) abrasion proportion to be practiced on tooth-supported prosthesis

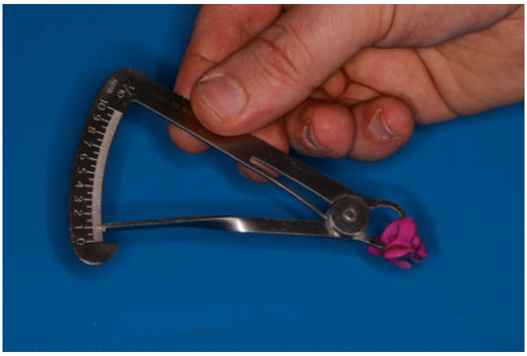

Fig. 7.9 Measuring whether the rest seat thickness is sufficient or not

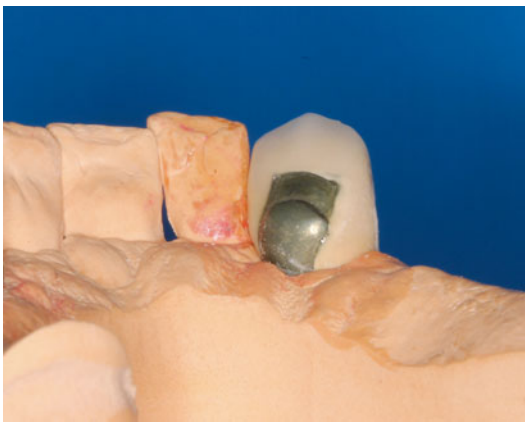

Fig. 7.10 Cingulum rest seat

7.3 Crowning the Supporting Tooth/Teeth

Determination of crowning the abutment teeth is usually performed in such cases that require repositioning of crown or occlusion, especially when the rest seats should be prepared on anterior teeth and/or when a clinical crown is fractured. After the decision of crowning the abutment teeth, sufficient space should be allocated during tooth preparation for esthetics, rest seats, and planned clasps. Especially on the area, where rest seats will be prepared, sufficient distance must be checked during tooth preparation (Fig. 7.12).

Since it is much more convenient to perform abrasions on the wax model, crowning of the abutment teeth should be initially controlled in wax modeling stage. Otherwise, these processes will be much harder to perform on metal.

If more than one crown will be prepared, all of the crowns should be replaced on the same model and then controlled on a surveyor.

While checking the wax model, the parallelism of the guide planes should be ensured and all of the proximal surfaces should be made parallel to each other by using the surveyor's cutting tip (Figs. 7.13 and 7.14).

Therefore, the metal framework will be seated appropriately according to the path of insertion. Food accumulation between the guide plane and

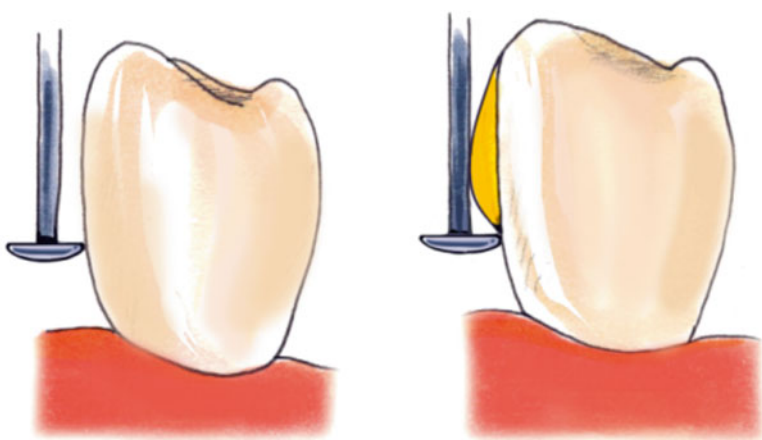

Fig. 7.11 Forming of undercut by composite in case of insufficient presence of undercut

the guide plate will be prevented, as there will not be any space in this area. It should be kept in mind that guide plane (guide surface) on the crown restoration should be prepared only with metal. After all of the guide planes are prepared, rest seats and retention should be reconsidered. If full metal crown is to be constructed, the height of contour should be marked with surveyor's marker tip, and undercut's sufficiency should be checked by undercut measuring tip. In order to easily see the height of contour on wax, a fine layer of powder can be applied on wax surfaces (Fig. 7.15a, b). If metal-porcelain crown is to be constructed for the abutment teeth, these processes should be done in dentine try-in (Fig. 7.16a, b).

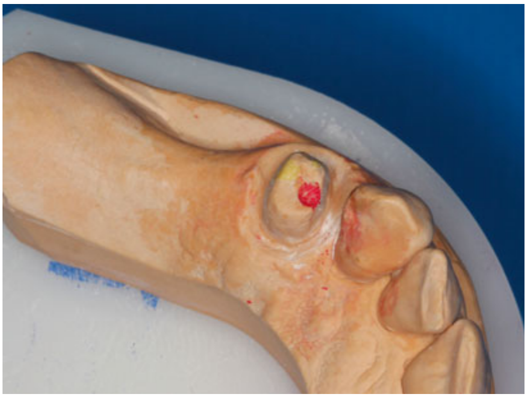

Fig. 7.12 Deeper preparation of insertion area of rest seat while tooth cutting (*red area*)

Fig. 7.13 Checking of parallelism of guide surfaces on wax model

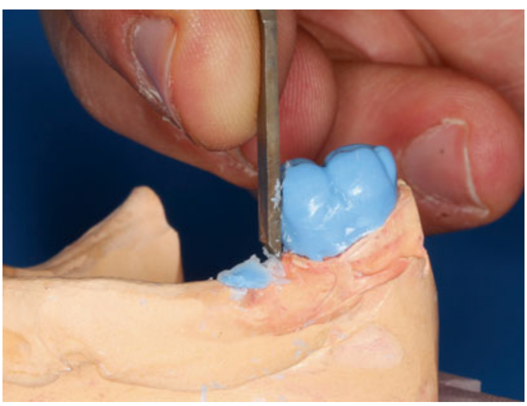

Fig. 7.14 Adjusting of nonparallel surfaces by use of surveyor's cutting tip

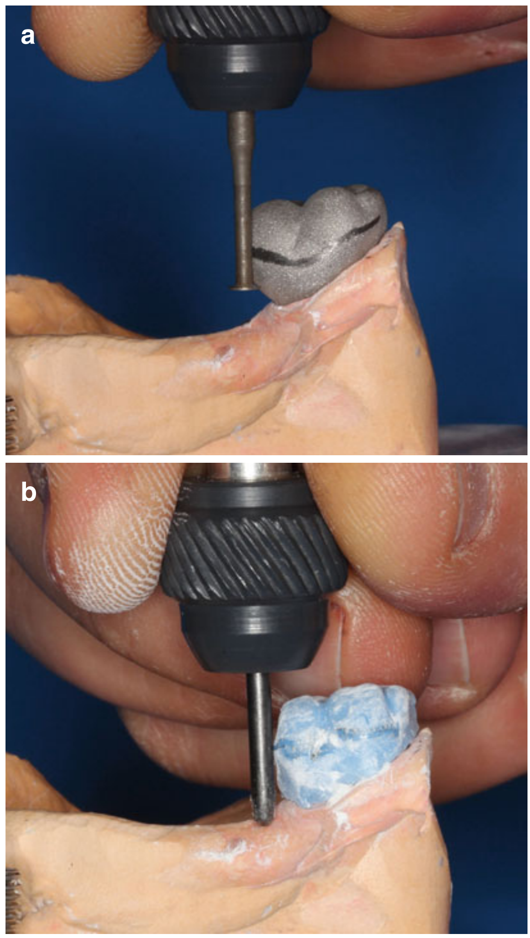

Fig. 7.15 Marking of the height of contour on full metal crown (**a**) and wax model (**b**)

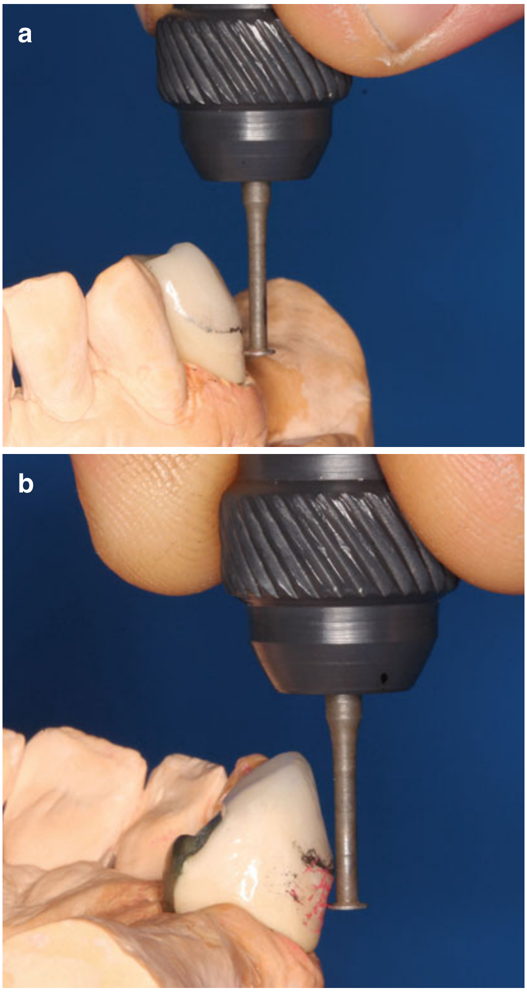

Fig. 7.16 Determining whether sufficient undercut is present or not during dentine try-in. (**a**) Insufficient undercut; (**b**) sufficient undercut

To maintain the stabilization and reciprocation, a step should be prepared on lingual/palatinal surface of the crown. Clasp reciprocation will provide both horizontal stabilization and indirect retention. Reciprocal arm is necessary to compensate the horizontal force that the retentive arm applies while wearing and removing the prosthesis. The force that retentive arm applies during wearing and removal is temporary but strong, so it can cause orthodontic movement and periodontal destruction. Real reciprocation cannot be achieved with a retentive arm that is on the height of contour of the tooth, because when the retentive arm moves away, it loses contact with the tooth or when the retentive arm passes the height of contour and is seated on the tissues completely, it cannot compensate the horizontal force that the retentive arm applies to the tooth. Real reciprocation can be achieved only if it is appropriate for the path of insertion, parallel to the guide planes and if a step for reciprocation arm is prepared. Thus, reciprocal arm can contact the tooth and compensate the force that retentive arm applies on the tooth from when it contacts the tooth until the prosthesis is seated on the tissues. Guide plane that is prepared for the reciprocal arm, in this way, can compensate the forces that are applied during wearing and removal of prosthesis. The step that is prepared on the crown also acts as a stop for the reciprocal arm and it supports occlusal rest and indirect retention (Fig. 7.17).

Another advantage of such a step is that it does not make a bulge on the tooth. Thus, the patient feels comfortable as the tooth's natural contour is not destroyed, and as it does not disturb the tongue. This step for the reciprocal arm is generally used on premolar and molar teeth, but it can be used on canine teeth, if necessary. The step should follow gingival inclination and it should have sufficient durability. The step that is prepared on the lingual surface should be carved by the surveyor's cutting tip after the path of insertion is determined and proximal guide planes and rest seats are prepared. Thus, proximal guide plates can continue to lingual surface and the step will be formed according to the path of insertion. Preparations that are made in wax modeling stage should be checked on the cast metal crown. In order to do this, all of the parallelism that is mentioned above should be controlled with a dental hand piece, which is attached to a surveyor.

Rest seats on the crown should have sufficient depth. During the tooth preparation, a deeper seat should be prepared on where rest will be seated. If this preparation is not accomplished during tooth preparation, it may not be possible to make rest seats with appropriate depth (Fig. 7.18). In addition, a rest that is seated on an inappropriate rest seat cannot completely achieve its function.

The location of rest seats should be decided in advance during tooth preparation.

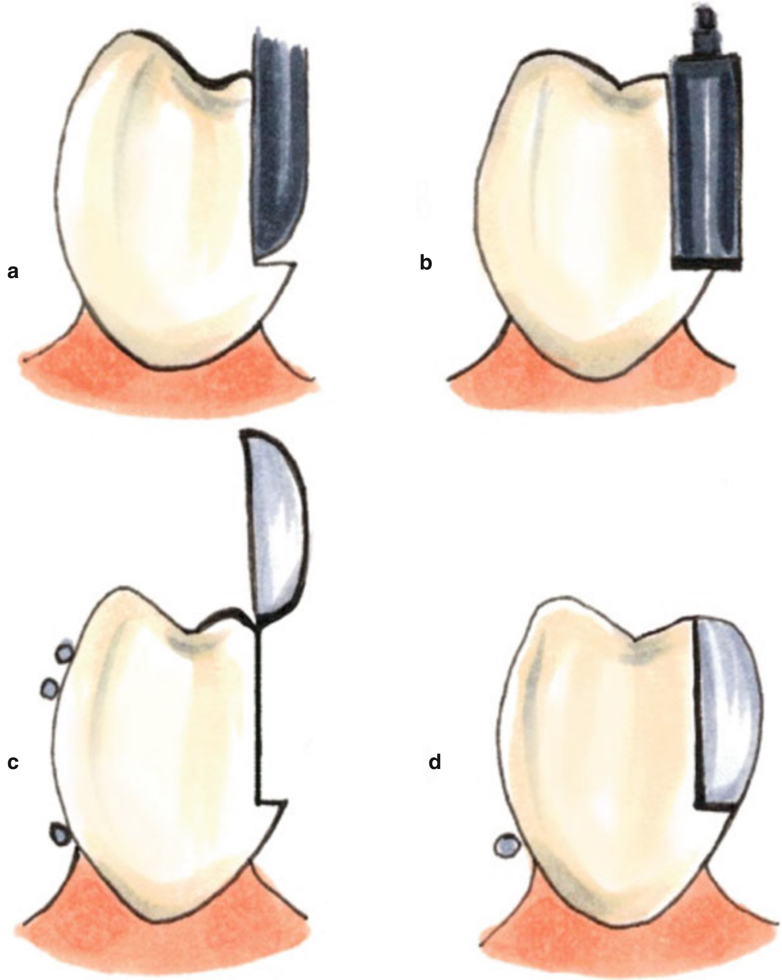

Fig. 7.17 (**a**, **b**) Adjustment of step according to prosthesis path of insertion by surveyor's knife. (**c**) Appropriate contact of reciprocal arm to prosthesis' path of placement and removal when the step is adjusted in this manner. (**d**) Accurately seated position of reciprocal arm

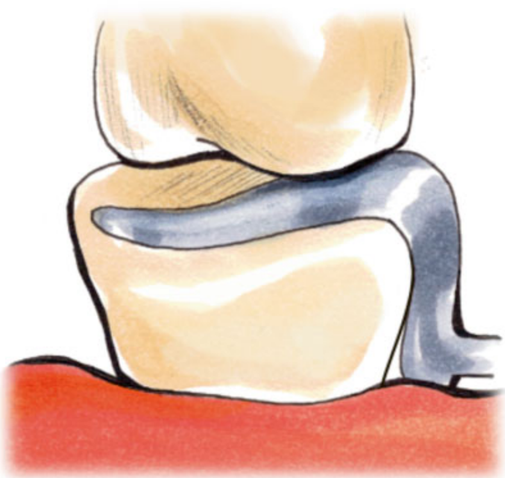

Fig. 7.18 Occlusal interferences may occur in case of insufficient depth of rest seats opened

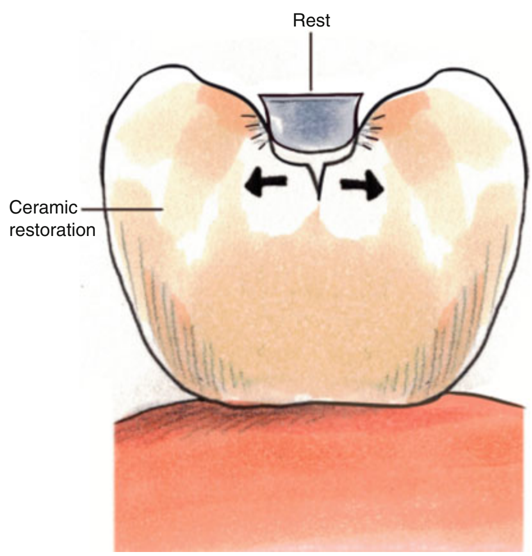

Fig. 7.19 Since rests may cause chipping and fracture on porcelain, they should always be seated into metal seat

While the crown is being constructed, if there is not sufficient space at wax modeling stage, this may cause various problems, such as occlusal interferences or fracture of the thin rest. Rest seats should always be prepared on metal, and it should be at least 1 mm away from the porcelain.

Despite the fact that porcelain is resistant to withstand compressive forces, it is not very resistant to tolerate tensional forces. Therefore, porcelain chipping is frequently seen on rest seats prepared on porcelain (Fig. 7.19).

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8 Impressions for Removable Partial Dentures

Burç Gençel

8.1 Tray Selection for Preliminary Impressions

Alginate impressions are conventionally made with perforated or non perforated rim-lock metal trays (Fig. 8.1a, d). The accuracy of an alginate impression is not only dependent on the surface detail but also on the strength of bond between the material and the tray. The mechanical bond between the impression material and the tray is secured by the rim-lock borders and/or perforations. Tray adhesives for alginate materials provide surface adhesion and they are available in spray or liquid form. If the impression is separated, even slightly, from the tray then it should be repeated. Trays without mechanical retentions may need additional retentive modifications for proper impressions. Impression compound, wax, and acrylic resin are the materials to customize stock trays, both to improve coverage area and to create mechanical areas of retention (Fig. 8.2a, b).

There are non metal trays, similar in shape with regular metal stock trays. These trays can be safely used for impression making if they are rigid enough to keep their shape during impression making; otherwise, they should be avoided even for diagnostic impressions (Fig. 8.1b, e).

Stock trays are present in assorted sizes. Besides regular small, medium, and large sizes, there are extra small pediatric trays and extra large trays (Fig. 8.1f). It is commercially impossible to fabricate stock trays for every possible type of partial edentulism so they are available in the shape to fit fully dentate jaws. However, there are stock trays for Kennedy Class I cases with dentate anteriors and edentulous posteriors. A few manufacturers also produce stock trays for Kennedy Class II cases (Fig. 8.1c).

Before making the impression, the tray should be tried in the mouth. It should cover all the relevant structures, and the impression material should be supported by the tray over the whole impression surface. When the stock tray does not fit properly, the borders must be corrected with wax, acrylic resin, or impression compound. The unsupported impression material may possibly deform during plaster pouring and that would result in a corrupt cast. There should be sufficient clearance between the tray and the oral tissues for an accurate impression. The amount of clearance changes according to the impression material chosen (Fig. 8.2). For alginate, it should be 4–5 mm as it shows plastic deformation beyond 50 % elastic deformation.

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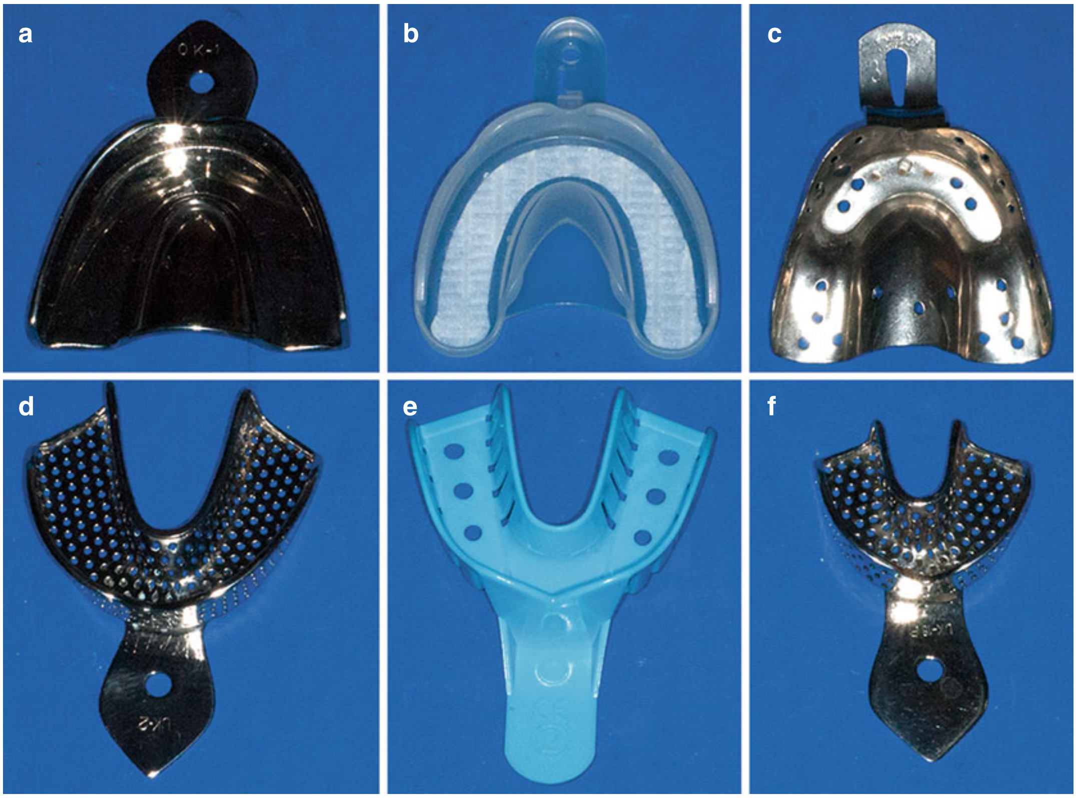

Fig. 8.1 Stock impression trays for preliminary impression. (**a**) Rim-lock, non perforated, metal stock impression tray. (**b**) Rim-lock, non perforated, rigid plastic stock impression tray. (**c**) Maxillary metal stock tray for Kennedy Class I cases with perforations and without rim-lock borders. (**d**) Rim-lock, perforated metal stock tray. (**e**) Plastic perforated tray with flat borders. Flexible and not suitable for RPD impressions. (**f**) Pediatric size impression tray

8.2 Final Impressions

Once the diagnostic cast is analyzed and pre-prosthetic preparations are completed, a new impression should be made. This is referred to as "the final impression" as it is the recording of the final state of the mouth with all the altered tissues.

Final impression can be a single step procedure as a modification of the preliminary impression. It may also be a multi step procedure when free-end saddles of a Kennedy Class I or Kennedy Class II case are desired to be finished on a separate impression. The aim is not only to precisely determine the functional borders of the distal extension denture base(s) but also to provide additional support by compressing the mucosa under functional loads. This is referred to as "functional impression" if it is made at chair-side in the control of the clinician. If a long-term corrective impression during function after the RPD is delivered to the patient is made then this is called a "muco-dynamic impression."

8.2.1 Tray Selection for Single Step Final Impressions

Stock trays can also be used for final impressions if the selected tray has suitable clearance from oral tissues for the selected impression material and sufficient coverage of the impression area. However, unless a conventional RPD is meant to be constructed without any mouth preparations with a single impression, it is best to use a custom tray that is prepared on the diagnostic cast. These are conventionally produced with self-curing acrylic or light-curing urethane dimethacrylate resins (Fig. 8.3).

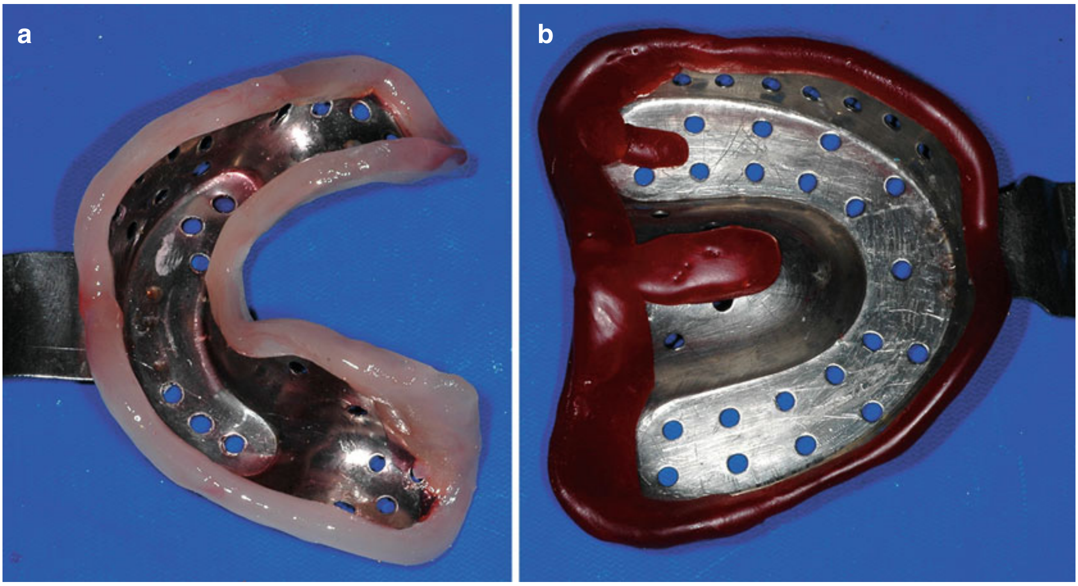

Fig. 8.2 Customization of stock impression trays. (**a**) Mandibular stock metal tray for Kennedy Class I case. Disto-lingual borders are extended and mechanical retention is provided with utility wax. Alginate adhesive is also applied to improve impression-tray bond. (**b**) Utility wax is added to the borders and the inner surface of the impression tray. The wax on the borders not only provides mechanical retention for the impression material but also helps to adjust the borders to cover all related structures. The clearance between the tray and oral tissues is customized with the wax added on the inner surface

Fig. 8.3 Custom tray for a Kennedy Class II RPD. Material is light-cure urethane dimethacrylate

Advantages of custom trays:

- They are rigid and dimensionally stable. They provide excellent support for the impression material.
- They are tailored to have superior fit to the impression area. They usually need little to no adjustments prior to impression making.
- The position of the tray on the diagnostic model can be transferred to the mouth with acrylic stops (Fig. 8.4).
- The clearance between the tray and the tissues can be adjusted prior to fabrication. Material-specific clearance delivers best possible results. Functional borders can be molded and surface details can be precisely captured (Fig. 8.4).
- They can provide mechanical retention and/or chemical adhesion to the impression material with custom perforations and adhesive agents; therefore, impressions can be removed safely from deep undercuts and other retentive areas without damaging the integrity of the impression.

8.2.2 Impression Materials for Single Step Final Impressions

Alginate is still an accepted choice for final impressions. It was reported to be in the curriculum of more than 60 % of dental schools in the

Fig. 8.4 Acrylic stops transfer the position of the tray from the diagnostic cast to the mouth. Borders and the clearance of the tray are also adjusted according to the materials chosen for impression making

Fig. 8.5 Final impression made with alginate and stock tray

USA and 70 % in Turkey. It delivers a single step, mucostatic impression with fair surface detail which is satisfactory for many RPD cases. However, the expansive borders, weak tear resistance, and limited surface resolution are a few drawbacks. Postimpression needs of the material may also cause problems. Particularly, the plaster should be poured immediately once the alginate is set and this mostly requires a skilled personnel if the dental laboratory is not nearby. However, there are extended pour type alginates which may allow the transfer of the impression to the dental laboratory without dimensional changes. They are also not suitable for the transfer of implant positions with either closed or open tray impressions.

The final impression procedure for a tooth-supported RPD is very much like the preliminary impression. These are mostly Kennedy Class III and IV cases. However, when the distal free-end edentulous space is short and the support from the free-end saddle is not crucial, then it is also valid for Kennedy Class I and II cases as well. Whole impression surface is captured with a single step impression made with a stock tray if it fits the arch sufficiently (Fig. 8.5).

A-type silicones, polyether reinforced A-type silicones, and polyether impression materials are current alternatives to alginate which deliver better surface detail and several other advantages. Some of these materials are improved to have hydrophilic properties, but this is a little misleading. It does not mean that they work precisely in wet environment like irreversible hydrocolloids. To achieve better results, the impression area should be dried before impression making. The hydrophilic property of these materials actually makes them friendly with dental stones. They can be applied with non perforated stock trays, or for further precise impressions custom trays can be used. Regardless of the type of tray, these materials should always be used with an appropriate tray adhesive. They serve perfectly with open and closed tray techniques in implant involved cases. They can also mold functional borders almost precisely with superior surface detail. They are more resistant to disinfectants and they can be safely transported to the dental laboratory without any dimensional changes (Fig. 8.6).

8.3 Handling the Impression

There are specific hints for each impression material and there are commons of impression making.

- Tray selection and modifications as well as the amount of clearance between the impression and the tray should be according to the material chosen.
- All precautions to secure the impression-tray bond should be taken. Providing mechanical

Fig. 8.6 Final impression made with a custom tray and polyether material

retention, using an appropriate adhesive or both may be crucial for the matter.

- Care must be taken not to entrap air in the impression material while loading the tray. Alginate should firmly be stuffed in with a stiff spatula. Dough-type materials should be well kneaded, rolled, and stuffed in the tray with finger pressure. When loading auto-mix materials, the tray should be filled from one side to another and the impression tip should always be kept in the flowing paste. It may be useful to wet undercut areas and teeth surfaces with the impression material before inserting the tray.
- Rima oris should be held open with a diagnostic mirror on one side and the impression tray on the other while inserting the tray. Lips should be pulled to cover the impression tray.
- The tray should be positioned with mild finger pressure giving the material time to make its thixotropic flow.
- The tray should be kept still with fingers on the premolar area during the setting of the material as any movement of the tray during setting will result in a defective impression.
- The tray should be pulled parallel to the long axis of teeth for easy and safe removal. A small initial movement will release the adhesion of the impression, and the lips should be pulled to let air to the impression-tissue interface.
- Once removed, the impression must be checked for material-tray integrity, surface details, and borders.
- After proper cleaning and disinfection, a suitable type of plaster should be poured. If an alginate impression is taken, it should be poured immediately.

8.4 Functional Impressions

The idea of making an impression of the functioning mucosa goes back a while. The aim is not only to cover as much area as possible but also to record the shape of the ridge within the limits of its resilience and fully employ the primary stress bearing areas in order to provide mucosa support for the free-end saddle. It is mostly meant for mandibular Kennedy Class I and II cases where mucosa support is weak. The maxillary coverage of an average RPD is much wider and the hard palate provides a firm support to the denture eliminating the need for a functional impression.

Several methods are introduced to clinical practice, yet there are basically three types of making functional impressions. After diagnostic cast is analyzed and mouth preparations are complete, the conventional technique, originally introduced by Applegate, describes a multi step impression in which a stock or occasionally a custom tray is used to make an overall impression only to design and construct the metal framework. The functional part of the impression is carried out after the framework is cast and the subsequent procedures are carried out on the new or modified cast. The other approach makes the use of a custom tray, which is prepared to make the final impression of all structures at a single appointment. In this concept, the master cast is poured and all following procedures, including the metal framework, are carried out on this final cast. Another option is to finish the denture without making a functional impression and then make an early reline.

8.4.1 The Altered Cast and Its Modifications

The classic altered cast technique was the first effective clinically applicable method that found ground in dental practice. The popular derivative

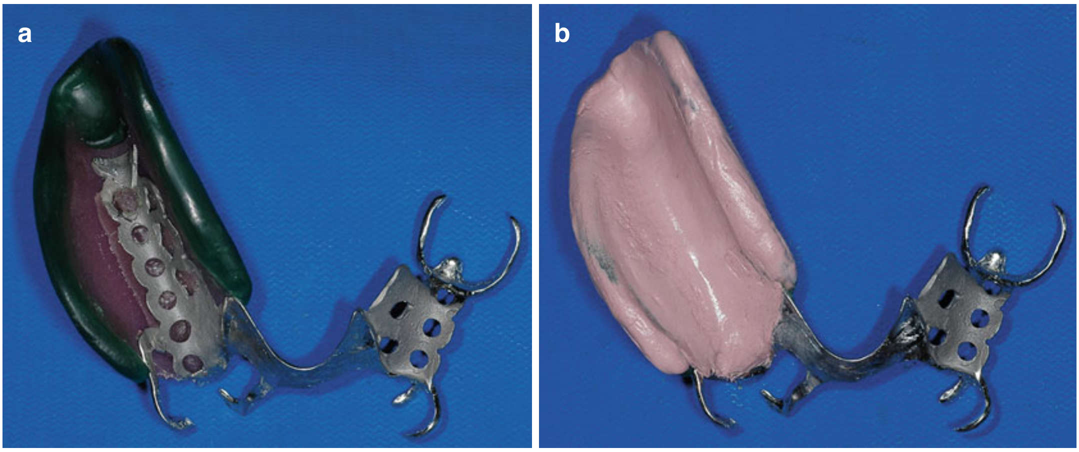

Fig. 8.7 (**a**) Acrylic saddle is border molded for functional impression. (**b**) Functional impression is completed with zinc oxide and eugenol paste

of the technique is a multi step procedure starting with a conventional impression, which is benefited to construct the metal framework. The metal framework is then used to make the impression of the free-end edentulous space(s) with the help of acrylic saddles built on the retentive gridwork. The saddles are treated like an individual tray for a complete denture, first the border is molded and then surface impression is made (Fig. 8.7a, b).

The alignment of the framework in each insertion is critical for the success of this procedure. To prevent any clinic born errors, during border molding and final impression, the framework should be fixed in position by pressing at least three supporting points at each insertion. These supporting points can be occlusal, cingulum, or incisal rests and the part of the major connector that provides tooth support, but the location of metal stops under the retentive gridwork should be avoided. In other words, while holding the framework in "position," pressure should not be applied on the saddles as the resilience of the mucosa, which we are trying to capture, may probably cause a rotational movement around fulcrum axis (Fig. 8.8). This will eventually lead to a faulty impression.

Once the functional impression is complete, the relevant parts of the initial cast is cut and the final cast is prepared by replacing the removed parts with the help of the impression made with the metal framework. The framework is seated and fixed on the grinded cast. The borders of the impression are boxed and plaster is poured as supplementary to former prepared cast. The final hybrid cast is then used for consecutive procedures (Fig. 8.9a–c).

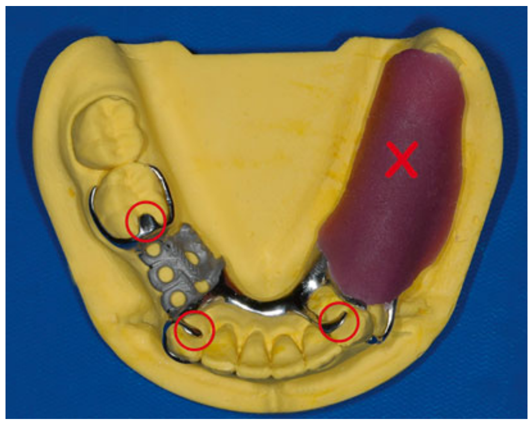

Fig. 8.8 Pressure points when the framework is seated. Pressure should not be applied on the acrylic saddle

This is a sophisticated method which needs delicate work even in the hands of an experienced clinician. The laboratory work is also critical not only when preparing the altered cast but also at previous stages. Any slight difference in the seating of the framework between the mouth and the cast, which is possible due to numerous reasons, may result in a defective cast as the alignment of the saddles with the rest of the mouth would not have been transferred correctly.

Once a defective cast is produced, it becomes complicated to proceed with the following steps. A new impression has to be made while the framework is seated in the mouth to provide a fresh working cast after which you can either choose to repeat the functional impression or to skip the step and make an early functional reline after the prosthesis is finished.

There is a wide spectrum of modifications made to simplify, shorten, and secure the outcomes of the process both regarding the materials used and the procedures applied. The corrective Korecta waxes used in the original method has almost been abandoned. The modeling impression compound stands out as the most popular border molding material available. Almost 80 % of dental schools in the USA and 100 % in Turkey are reported to be using impression compound for functional borders. Alternatives to impression compound are light-cured composite resin, utility wax, zinc oxide and eugenol paste, and tissue conditioners, and the materials used for final surface impression are polysulfide, polyether, polyvinyl siloxane, zinc oxide and eugenol paste, and tissue conditioners.

The laboratory procedures of making a hybrid cast is also a sensitive procedure, which can ruin the delicately made clinic work. To eliminate the risks in the process of cast altering, an overall impression over the finished functional impression in place can be made; thus, the position of the framework, as it is in the mouth, can be transferred to the new cast along with the functionally shaped surfaces. This can be done with stock trays and one of any elastic impression materials available (Fig. 8.10). Care must be given to prevent any movement of the framework while making the cover impression. If the impression material

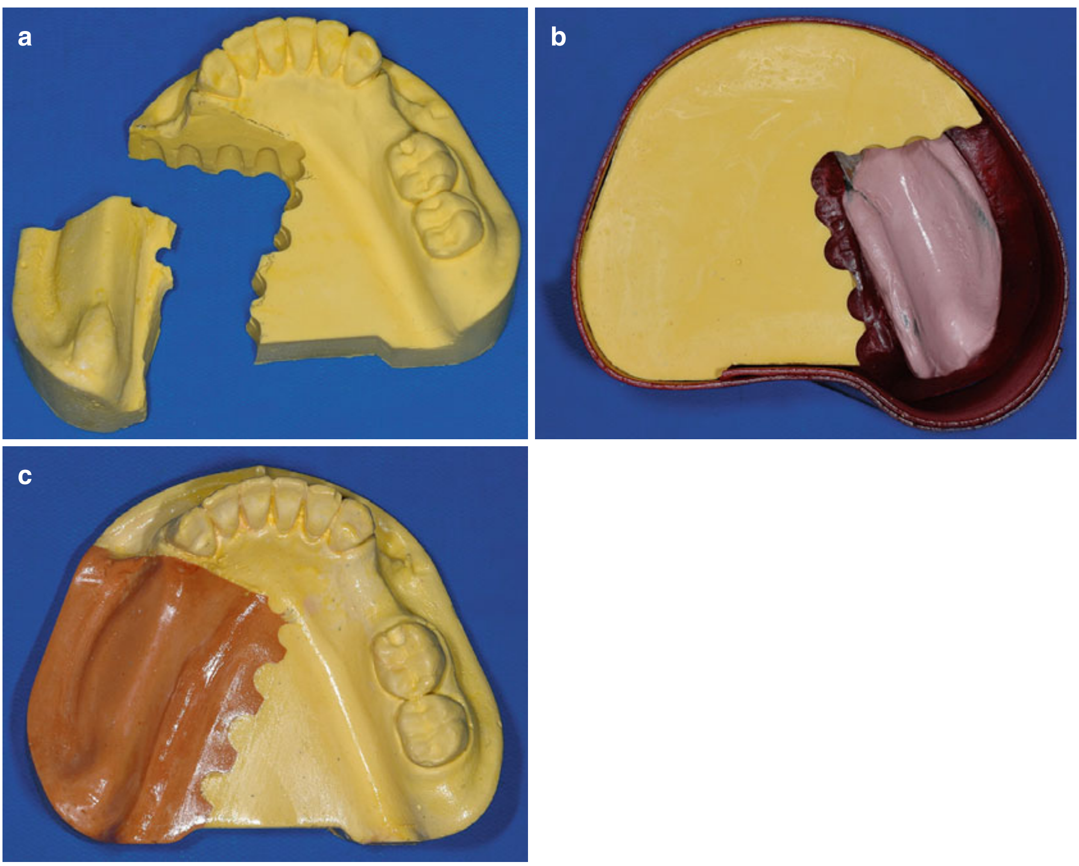

Fig. 8.9 (**a**) The cast is cut before transferring the final impression. The free ridge is cut away and retentive grooves for the supplementary plaster are prepared. (**b**) Functional impression is seated on the initial cast, fixed, and boxed. (**c**) The plaster is poured and the altered cast is ready

leaks to the functional impression-mucosa interface that means a hyper expansive impression is made and the framework has moved from its place during the procedure. The cover impression should either be short of the functional impression borders or it should flawlessly continue expansively. If it is short, the exposed borders of the functional impression are boxed, if it is expansive and masking the borders than the expansive material is cut away to clear functional borders before pouring the cast (Fig. 8.11a, b).

Fig. 8.10 Overall impression to transfer the functional impression to the final cast

8.4.2 Single Tray Functional Impressions

This is actually a derivative of single step final impression with a custom tray. The custom tray is shaped similar to the acrylic saddles in the altered cast technique over the free-ending edentulous ridge and the dentate area is produced in the conventional manner. The clearance between the tray and the cast is adjusted according to the impression material to be used. Acrylic stops over teeth keep the tray position during impression making.

The clinical procedure is first to make functional part of the impression with one of the border molding materials and then to make an overall wash impression with one of the elastomeric impression materials (Fig. 8.12a, b). This single piece impression is relatively simple, time saving, and easy to process. All parts of the RPD including the metal framework are produced on this final cast. Furthermore, the clinical outcomes of altered cast technique and single step functional impressions are reported to be similar (Fig. 8.13).

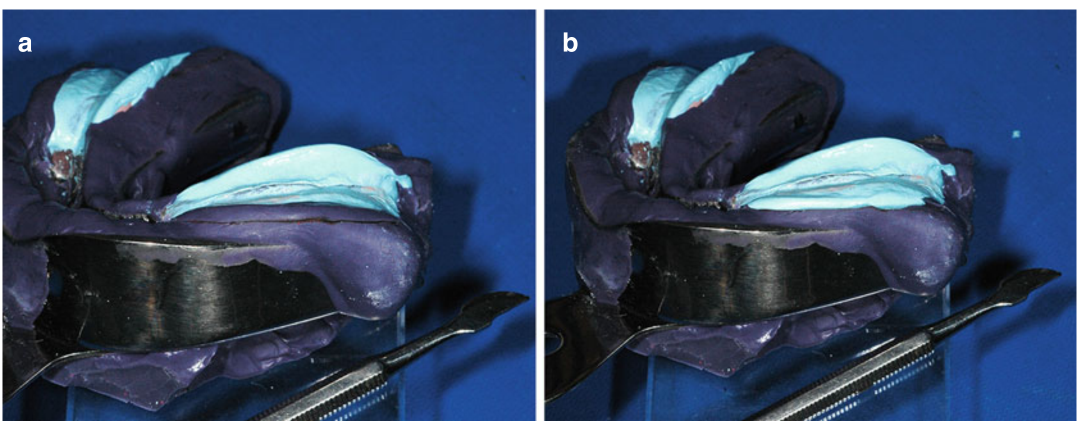

Fig. 8.11 (**a**, **b**) The overextended overall impression is cut at the boxing level to clear the functional borders; thus, the borders can be seen on the master model

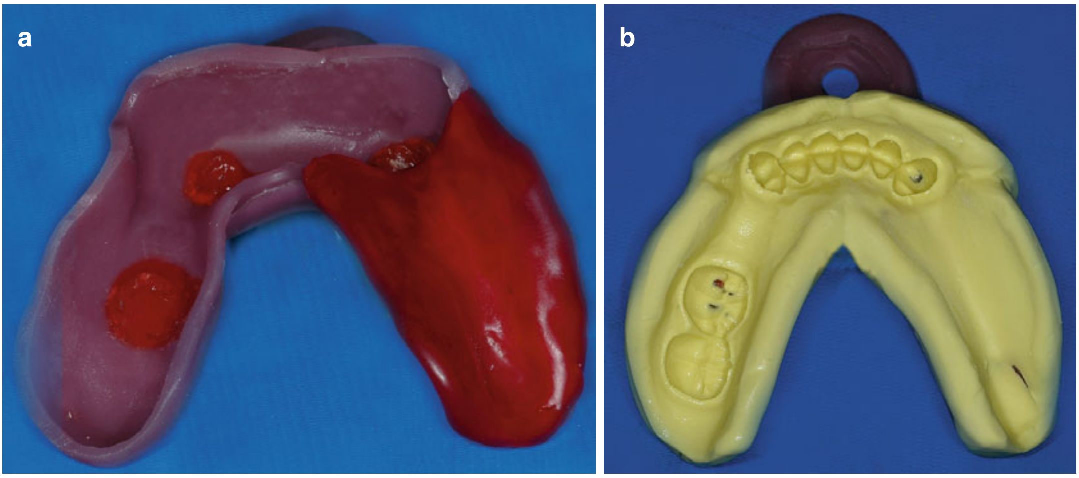

Fig. 8.12 (**a**) Border molding of the custom tray. Tray adhesive is applied on both the tray and the impression material. (**b**) Impression completed with polyvinyl siloxane

Fig. 8.13 Single piece cast from the single tray functional impression

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Part III

Clasp Retained Removable Partial Dentures

Major and Minor Connectors

9

Olcay Şakar

9.1 Definitions

Cross-arch stabilization Resistance against dislodging or rotational forces obtained by using a partial removable dental prosthesis design that uses natural teeth on the opposite side of the dental arch from the edentulous space to assist in stabilization

Guiding (guide) planes Vertically parallel surfaces on abutment teeth and/or dental implant abutments oriented so as to contribute to the direction of the path of placement and removal of a removable dental prosthesis

Major connector The part of a partial removable dental prosthesis that joins the components on one side of the arch to those on the opposite side

Minor connector The connecting link between the major connector or base of a partial removable dental prosthesis and the other units of the prosthesis, such as the clasp assembly, indirect retainers, occlusal rests, or cingulum rests

Path of placement The specific direction in which a prosthesis is placed on the abutment teeth or dental implant(s)

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9.2 Major Connectors

A removable partial denture (RPD) framework includes five components: major connector, minor connectors, rests, direct retainers, and indirect retainers (in distal extension RPDs) (Fig. 9.1).

RPDs should be designed according to biomechanical and hygienic principles (see Chap. 4).

Although design is a very important stage in the fabrication of the RPDs, unfortunately, dentists have a minimal input on this issue, and they leave it to the dental technician. This results in the common usage and preference of the technician's familiar designs (like the U-shaped maxillary major connector, considered the least preferable option). This chapter summarizes the major and minor connector designs, giving lots of samples for every Kennedy classification. Thus, dentists can easily create the most suitable design for their patients.

A major connector combines all other components of an RPD so that the partial denture acts as one unit. Thus, functional loads can be distributed to all abutment teeth, and cross-arch stabilization can be provided. In addition, in distal extension RPDs, forces can be distributed between both the abutment teeth and the mucosa by unification of the direct retainers with the denture base.

O. Şakar (ed.), *Removable Partial Dentures: A Practitioners' Manual*,
DOI 10.1007/978-3-319-20556-4_9

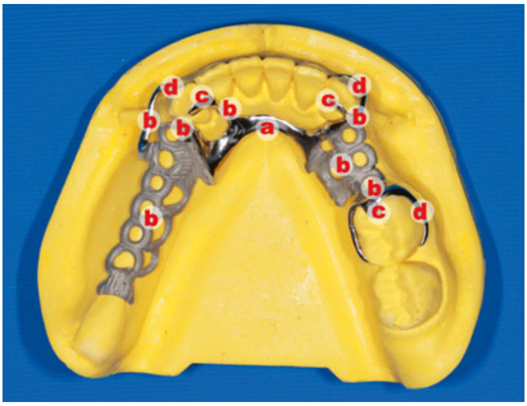

Fig. 9.1 The components of a removable partial denture framework: (*a*) major connector, (*b*) minor connectors, (*c*) rests (rest and minor connector on the right canine serve as indirect retainer), and (*d*) direct retainers

Fig. 9.2 All major connectors' borders should run parallel to the gingival margins of the remaining teeth. Borders of a mandibular major connector should be placed at least 3–4 mm away from the free gingival margins

9.2.1 General Aspects of Major Connectors

All major connectors should have the following characteristics to function effectively and to protect the teeth and soft tissues:

1. Major connectors should:
   (a) Be rigid
   (b) Have smooth and rounded line angles
   (c) Conform to anatomic structures
   (d) Not interfere with movable tissues
   (e) Not allow food entrapment
   (f) Not cover more tissue than necessary
   (g) Not use marginal gingiva for support
   (h) Not impinge on soft and hard tissue prominences or gingival tissue during placement, removal, or function
2. Borders of a major connector should:
   (a) Run parallel to the gingival margins of the remaining teeth in both arches (Figs. 9.2 and 9.3).
   (b) Be placed at least 3–4 mm away from the free gingival margins *in the mandibular arch* (Fig. 9.2). Otherwise, the major connector should cover the lingual surfaces of the teeth as a plate. On the anterior teeth, the plate should cover the cingula but not be higher than the middle third of the teeth, except to cover the interproximal spaces at the contact points. On the posterior teeth, the plate should end at the height of the contour *in both arches*.
   (c) Be placed at least 6 mm away from the free gingival margins *in the maxillary arch.* Otherwise, the major connector should cover the lingual surfaces of the teeth as a plate (Fig. 9.3).
   (d) Not end on the crest of rugae or at the free gingival margin (Fig. 9.4).
   (e) Cross the maxillary midline at right angles, not diagonally.

Fig. 9.3 Borders of a major connector should not be placed on the free gingival margin, instead running away from the margins (at least 6 mm). Otherwise, it should be extended as a plate

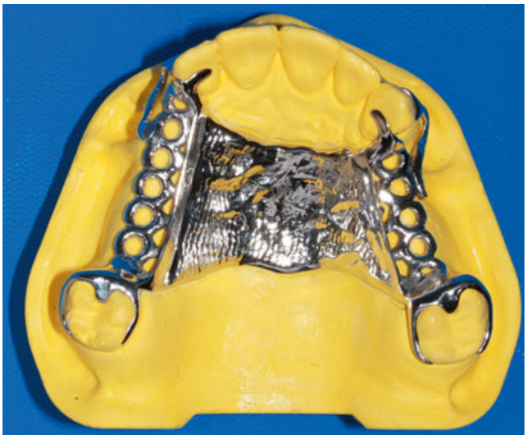

Fig. 9.4 The rugae should be replicated anatomically, and borders of major connectors should not end on the crest of rugae

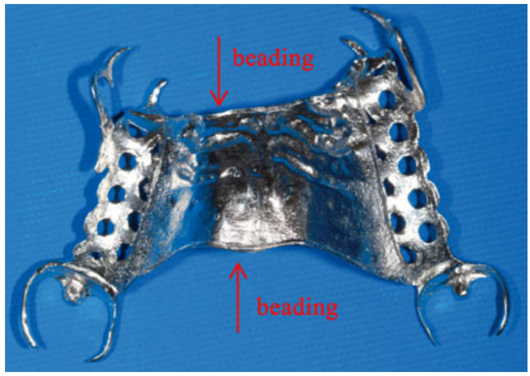

Fig. 9.5 Bead lines are used in all maxillary major connectors, not in mandibular major connectors

(f) Be beaded to increase the adaptation, to prevent debris from collecting beneath the major connector, and to minimize the casting shrinkage *in all maxillary major connectors* (0.5–1 mm wide and deep) (Fig. 9.5). Beading is not necessary in the mandibular major connector.

3. *Relief* is not required except for a palatal torus or prominent median palatal suture area in the *maxillary major connectors*, but it is often necessary between the rigid metal surfaces and the underlying soft tissues in the *mandibular major connectors.*

9.2.2 Maxillary Major Connectors

1. *Anteroposterior palatal strap*
   (a) It can be used for Kennedy Class I, II, III, IV, and V partially edentulous arches (Fig. 9.6a–d).
   (b) It is structurally rigid with minimum bulk.
   (c) The anterior and lateral straps should be 6–8 mm wide. The posterior palatal strap can be 4 mm wide to increase patient comfort.
   (d) The palatal opening should be 15 mm or more in an anteroposterior dimension.
   (e) The anterior strap should not be placed beyond the most anterior rests.
   (f) The posterior strap should be placed as far back as possible but should not be in contact with the tissues of the movable soft palate.
   (g) When the presence of an inoperable torus that ends posteriorly 6–8 mm from the anterior of the junction of the hard and soft palates, an anteroposterior palatal strap can be used.
2. *Palatal strap*
   (a) It is used in Kennedy Class III and VI partially edentulous arches if edentulous spaces are short (Fig. 9.7).
   (b) The rigidity provided by a palatal strap is usually adequate if the anteroposterior dimension of a strap is a minimum of 8 mm.
   (c) If there is a large torus, palatal strap should not be used.

The anteroposterior palatal bar and the *palatal bar* mentioned in many textbooks are variations of the anteroposterior palatal strap and the palatal strap major connectors. They should be bulky in order to be rigid, and thus they are generally unacceptable for many patients and not recommended.

3. *Palatal plate*
   (a) It is essentially used in Kennedy Class I partially edentulous arches where six or less anterior teeth remain, the abutments are periodontally weakened, and/or the support from the residual ridges is poor (Fig. 9.8a).
   (b) It is structurally rigid.
   (c) It covers one half or more of the hard palate.

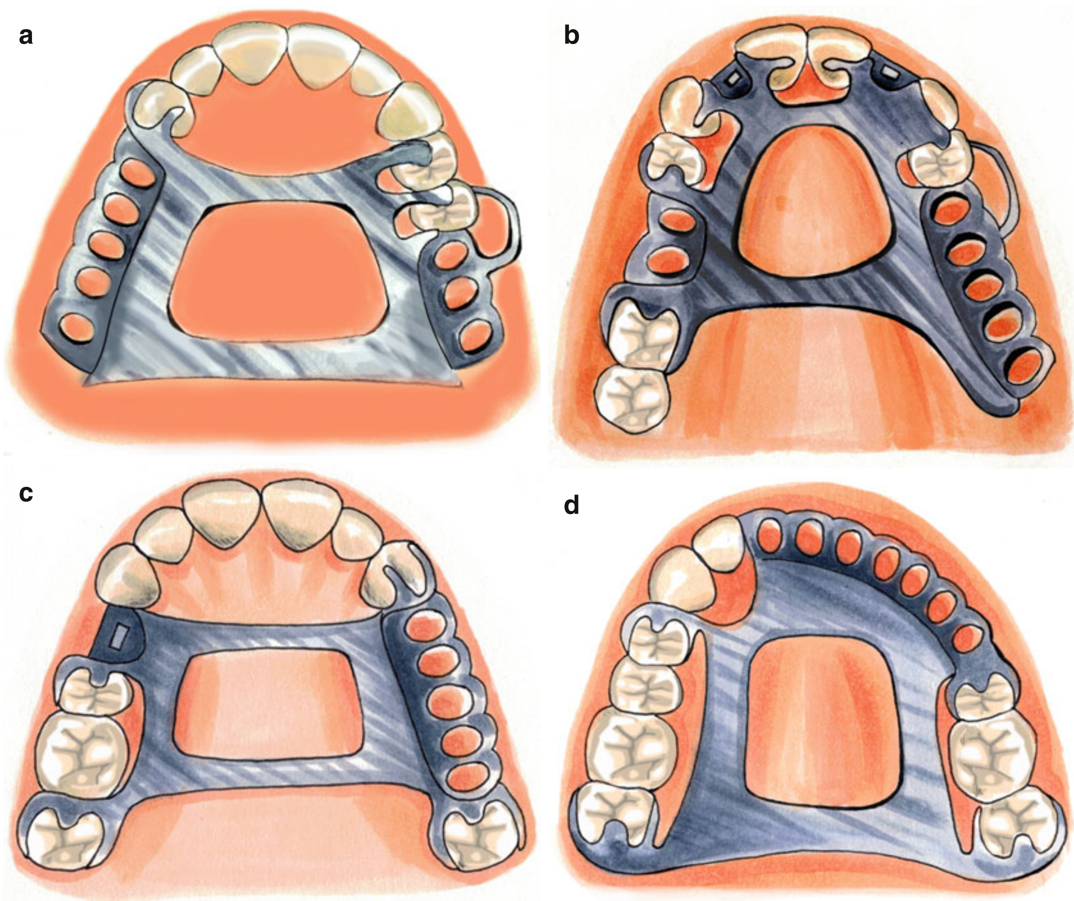

Fig. 9.6 (**a–d**) An anteroposterior palatal strap major connector can be a desirable choice for all maxillary arches except Kennedy-Applegate Class VI arches having short edentulous space. While anterior and lateral straps should be 6–8 mm wide, posterior strap should be 4 mm wide. The design example shown in (**d**) can also be used in Kennedy-Applegate Class V cases having weak anterior abutment. In distal extension bases, wrought wire retentive arms are indicated where clasp tips lie in front of the axis of rotation. For example, in the cases shown in Fig. 9.6a, a wrought wire clasp can be used on the right canine abutment tooth

(d) The posterior border extends to the junction of the hard and soft palates. The posterior palatal seal that is used with complete dentures should not be utilized unless the posterior part is made of acrylic resin as seen in Fig. 9.8b; instead, a slight mechanical seal may be formed by ensuring the presence of a bead line along the posterior border of the major connector.

(e) If there is a large torus, palatal plate should not be used.

(f) Three forms of the palatal plate can be used for different cases:

1. It can cover two-thirds of the palate. The anterior border does not extend beyond the most anterior rests.
2. The posterior part of the palatal plate can be formed as a gridwork design with the possibility of adding acrylic resin. This form allows for future relining (Fig. 9.8b).
3. Linguoplating can be used for indirect retention or subsequent replacement of natural teeth.

Modified palatal plate connector: It is used in Kennedy Class II partially edentulous arches. Anteroposterior dimension and form is done as palatal strap and continued backward,

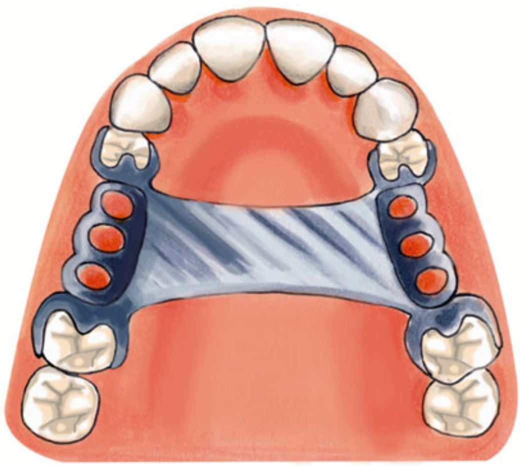

Fig. 9.7 A palatal strap major connector can be used in Kennedy Class III and Kennedy-Applegate Class VI arches having short edentulous spaces. Its anteroposterior dimension should be minimum of 8 mm

ending with a butt joint at the entrance to the hamular notch. The posterior border may not be extended to the junction of the hard and soft palates (Fig. 9.9).

4. *U-shaped or horseshoe*
   (a) It is not structurally rigid, especially for the Kennedy Class I and II partially edentulous arches.
   (b) It is only used in cases with a prominent median suture line and if an inoperable torus extends to the posterior limit of the hard palate (Fig. 9.10). It can be used when the patient insists on the use of her/his old denture's design, which is U-shaped, or when he/she thinks they cannot tolerate the posterior portion of the major connector. When it is used, the thickness of the framework should be increased if maximal rigidity is desired. This can be accomplished by the use of two layers of pattern wax when the framework is made.

Rigidity is a very important factor which should be taken into consideration for major connectors because it has been shown that the rigid major connectors decrease both RPD and abutment tooth movement under loading. As described above, a major connector requires a minimum

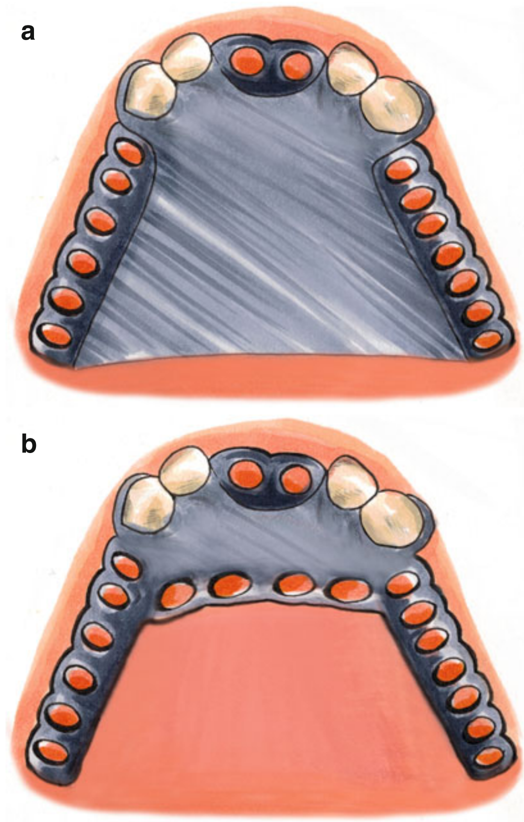

Fig. 9.8 (**a**, **b**) When maximum tissue support is necessary, a palatal plate major connector can be used. Posterior part of the major connector can be formed as a gridwork design. Wrought wire retentive arms can also be used on the canine abutments

Fig. 9.9 A modified palatal plate major connector used in Kennedy Class II cases

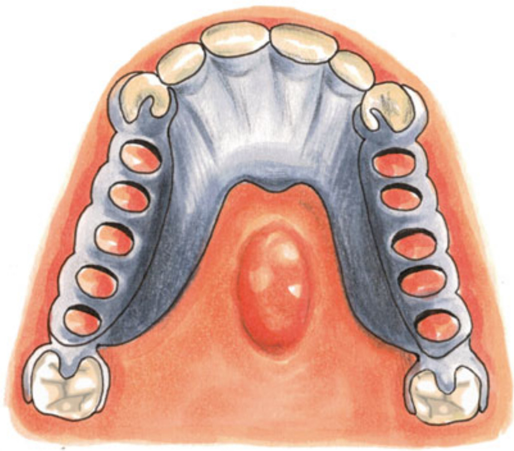

Fig. 9.10 A "U-shaped" or horseshoe major connector. Its use is limited because the rigidity is not sufficient

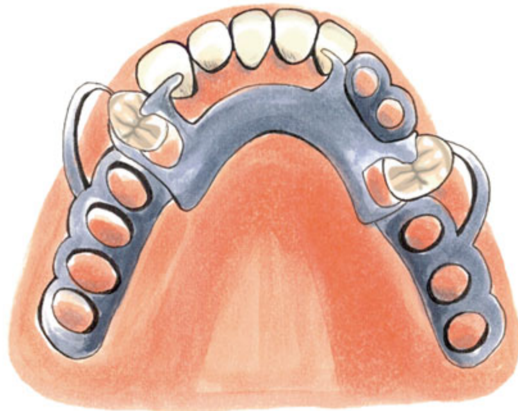

Fig. 9.11 If there is at least 7 mm vertical distance between the floor of the mouth and the gingival margins of the teeth when the tip of the patient's tongue is touching the anterior part of the palate, a lingual bar major connector can be used

size for rigidity. Therefore, it is not recommended to reduce the metal framework for all types of major connectors.

9.2.3 Mandibular Major Connectors

1. *Lingual bar*
   (a) It is structurally rigid if it is designed to a height of 4 mm and a thickness of 2 mm and is half pear-shaped in cross section with the thin edge toward the teeth (Fig. 9.11).
   (b) The superior border of the bar should be 3 mm below the gingival margins. Therefore, it requires at least 7 mm of vertical space between the floor of the mouth and the gingival margins of the teeth when the tip of the patient's tongue is touching the anterior part of the palate.
   (c) It cannot be used when a large inoperable torus exists (Fig. 9.12).
2. *Lingual plate*
   (a) It is structurally rigid.
   (b) It is an extended version of a lingual bar with a thin metal plate. The metal plate should cover the cingulum of the anterior teeth and the superior border must be scalloped (Fig. 9.13).
   (c) When interproximal spaces exist between the anterior teeth, "stepbacks" can be designed to avoid display of metal.

Fig. 9.12 In cases having large inoperable lingual torus, a lingual plate major connector should be used

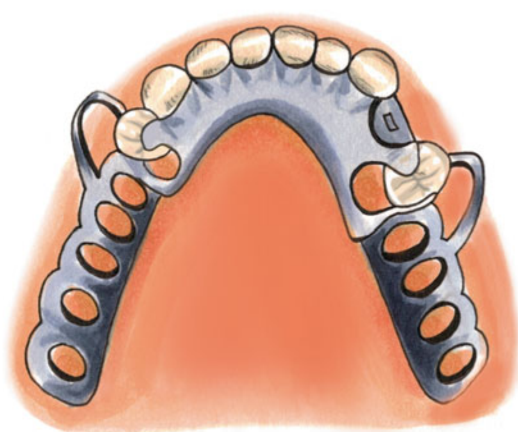

Fig. 9.13 The metal plate should cover the cingulum of the anterior teeth when a lingual plate major connector is used

(d) It should have a terminal rest at each end regardless of the need for indirect retention.
(e) It can be used in the presence of inoperable mandibular tori.

The *Kennedy bar (double lingual bar/continuous bar)*, which is indicated when the axial alignment of the anterior teeth needs excessive blockout for the lingual plate and wide diastemata exist, and the *labial bar*, which is indicated when excess lingually inclined anterior teeth exist, are mentioned in many textbooks. Both of them can create a food trap and can be disturbing to patients. Thus, they are not a practical solution, either esthetically or functionally, and are not mentioned in this chapter.

In case the interocclusal distance is too limited to set up regular artificial teeth or due to existing deep-bite (severe vertical overlap), occlusal or palatal surfaces may be added to the framework design which can be engaged with veneering materials. This option allows easy handling of the posterior edentulous space and eliminates the risk of acrylic base fracture (Fig. 9.14). Additionally in the presence of short spaces, insufficient room to set up artificial teeth can be closed only with metal if it does not cause esthetic problem. This will prevent food impaction and the migration of the teeth (Fig. 9.15).

Fig. 9.14 An interim removable partial denture with metal occlusal surface. Metal occlusal or palatal surfaces can be used in cases having insufficient interocclusal distance and severe vertical overlap

9.3 Minor Connectors

9.3.1 General Aspects of Minor Connectors

1. Minor connectors provide rigidity and unification by joining other components of a framework to a major connector. Thus, the transmission of forces among the major connector, abutment teeth, and oral tissues can be achieved.
2. Minor connectors act as a bracing component and maintain the path of insertion when they are located on guiding planes.
3. Minor connectors should be rigid (except the fourth type) and placed so as not to irritate the surrounding tissues.

9.3.2 Types of Minor Connectors

1. Minor connectors that join clasp assemblies to major connectors. As they may be attached to the clasps, they can also be a separate entity
   (a) Mostly, they are located on guiding planes or surfaces. Sometimes, it is necessary to put them on a tooth surface adjacent to another tooth. In this situation, it should be positioned in the associated lingual embrasure.

Fig. 9.15 If there is a short edentulous area which is not in the esthetic zone, it can be filled with metal only to prevent food impaction and the migration of the teeth

(b) When it is formed as a separate entity, it should be approximately 1–1.5 mm thick, tapering both occlusally and facially. It is shifted slightly toward the lingual side to increase rigidity and enhance reciprocation (Fig. 9.16).
(c) The guide (proximal) plate minor connector should cover about half the distance of the abutment tooth buccolingually (between tips of buccal and lingual cusps) and two-thirds the distance of the tooth occlusogingivally. It is effective to prepare a guide plane as close to the gingival margin as possible to reduce the plaque accumulation (Figs. 9.16 and 9.17).
(d) In distal extension RPDs, the proximal plate is in contact with the entire guiding plane initially, but physiologic relief is necessary at the framework try-in. In tooth-supported RPDs, guiding plane preparation and proximal plates are generally longer, and physiologic relief is not necessary. An elongated proximal plate that is parallel to the path of insertion may compensate for the loss of retention when an adequate guiding plane cannot be prepared.
(e) If tooth surfaces are parallel to the path of placement, preparation of the guiding plane is not necessary. (Preparation of the guiding planes on the abutment teeth is described in chapter 7.)

Fig. 9.16 If a proximal plate minor connector can be formed as a separate entity, it is shifted slightly toward the lingual side

Fig. 9.17 A proximal plate minor connector should be placed on the guiding plane covering about two-thirds of the tooth occlusogingivally

2. Minor connectors that join indirect retainers or auxiliary rests to major connectors
   (a) They should be positioned in embrasures and should form right angles with the major connector, and junctions should be rounded. Although one study proposed to place minor connector on the center of the lingual aspects of the maxillary abutment tooth to reduce the amount of gingival tissue coverage, more randomized clinical studies are needed to change the classical knowledge.
3. Minor connectors that join denture bases to major connectors
   (a) They can be constructed in different designs such as mesh design, ladderlike design, loop design, or metal base with different retentive elements (such as bead, nailhead). Metal bases can be used instead of acrylic resin bases in tooth-borne removable partial dentures where the short edentulous spaces exist (Fig. 9.18). Large openings in a retention design are generally more satisfactory than a mesh design which may result in further weakening of the resin (Fig. 9.19). Additionally,

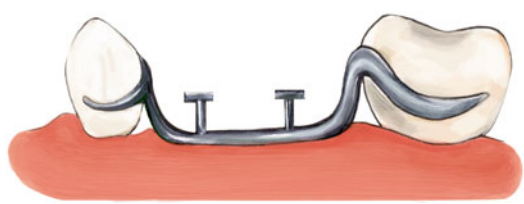

Fig. 9.18 Tissue surface can also be fabricated with metal in cases where tissue support and future relining are not necessary

Fig. 9.19 Large-opening gridwork designs such as ladder-like and loop designs (*right*) are more preferable than mesh design (*left*) considering the acrylic retention. But the thickness of these designs can complicate artificial tooth setting

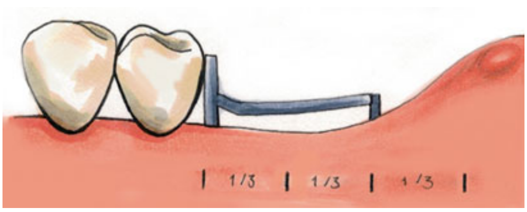

Fig. 9.20 In mandibular distal extension removable partial dentures, gridwork minor connector should not be placed on the ascending portion of the ridge

Ohkubo et al. recommended that the three structural designs which are superior to conventional design may also be considered along with the conventional designs.

(b) In Kennedy Class I and II mandibular arches, the minor connector should extend about two-thirds the length of the edentulous ridge but should not be placed on the ascending portion of the ridge. It should be extended on both buccal and lingual surfaces (Fig. 9.20).

(c) In Kennedy Class I and II maxillary arches, they should be extended as far as possible posteriorly, and the junction of major and minor connectors should be located 2 mm medially from an imaginary line that would come into contact with the palatal surfaces of artificial teeth.

(d) In free-end saddle partially edentulous cases, they must be finished with a "cast stop." Altered cast impression procedures result in an elevated cast stop from the residual ridge. The autopolymerizing acrylic resin can be added to compensate for this gap (Fig. 9.21a–c).

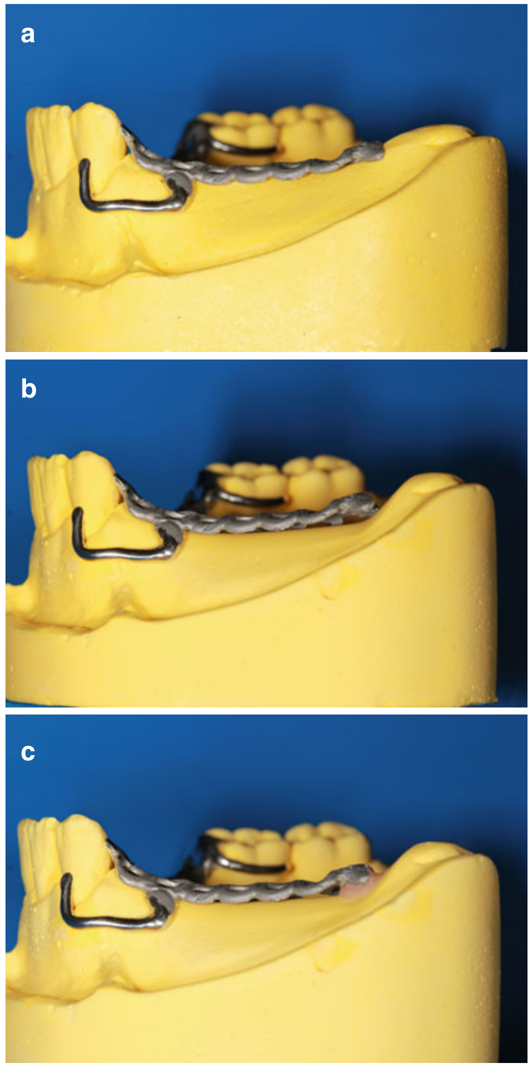

Fig. 9.21 (**a–c**) Metal cast stop can be modified with self-cure acrylic resin, if an altered cast impression has been performed

(e) Relief under the minor connector should be started 1.5–2 mm away from the abutment tooth. Thus, metal/tissue contact can be created in this area.

(f) A butt joint should be used to design the resin-metal interface (finishing line). The finishing line junction with the major connector should take the form of an angle not greater than 90°, therefore being somewhat undercut.

4. Minor connectors that serve as approach arms for vertical projection/bar-type clasps

These minor connectors support the clasps and do not need to be rigid (Fig. 9.1).

Different study results showed that there was insufficient evidence to determine whether one design was better or worse than another regarding major/minor connectors and direct retainers in mandibular distal extension RPDs. Removable partial dentures will not have any harmful effects on the remaining teeth and periodontal tissues if they are properly designed and oral hygiene is checked regularly.

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10 Rests and Rest Seats

Olcay Şakar

Rests are vital for removable partial dentures to perform their optimal function. In addition to their several advantages described in this chapter, their most important benefits are preventing the removable partial denture movement toward the tissue and transmitting the occlusal forces in a way that will not harm the abutment teeth. Their proper function can only be achieved, if they seat on the well-prepared rest seats. Unfortunately, rest seat preparation is overlooked by many dentists and preparations' size and shape shows variety even between the prosthodontists. In this chapter, different forms of the rests, their appropriate rest seat preparations, and bonded rest seats are described along with the necessary equipment.

10.1 Definitions

Partial denture rest A rigid extension of a fixed or removable dental prosthesis that prevents movement toward the mucosa and transmits functional forces to the teeth or dental implant.

Rest seat The prepared recess in a tooth or restoration created to receive the occlusal, incisal, cingulum, or lingual rest.

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10.2 Functions of the Rests

Rests are used to:

1. Transmit the occlusal forces from the prosthesis to an abutment along the long axis of the tooth (Fig. 10.1)
2. Resist the denture base movement toward the soft tissue
3. Prevent impingement on the gingival tissues
4. Maintain clasps in the desired positions
5. Prevent extrusion (displacement-migration) of the unopposed abutment teeth
6. Act as an indirect retainer in Kennedy Class I, II, and long-span IV partially edentulous arches (see Chap. 11)
7. Provide correct location of the denture in rebasing or altered cast impression procedures
8. Reestablish occlusion (Fig. 10.2)
9. Prevent food impaction (Fig. 10.2)
10. Contribute to horizontal stabilization when placed on the anterior teeth

10.3 Forms of Rest and Rest Seat Preparations

As a rule, a rest should be placed in the prepared rest seat. The rest seat preparation has to be performed in the manner described below in order to ensure the proper function of the rests. Preparations should be fabricated without

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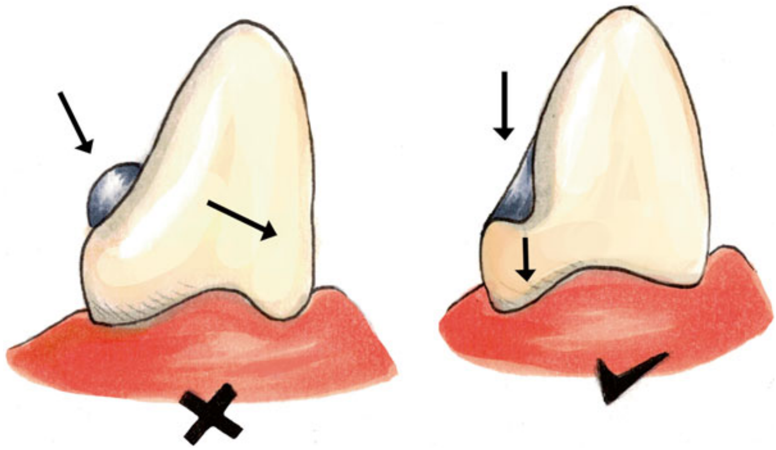

Fig. 10.1 A rest should be placed into a prepared rest seat. Otherwise, occlusal forces cannot be transmitted from the denture to an abutment along the long axis of the tooth

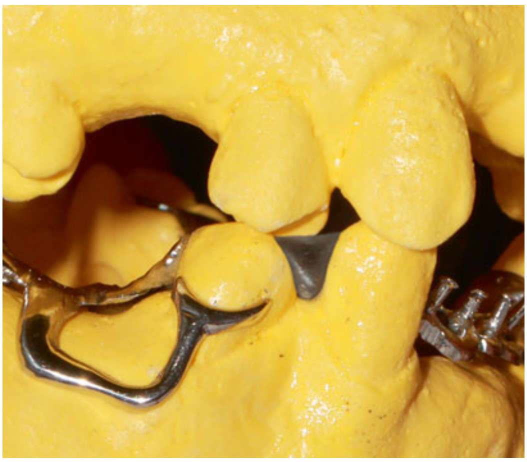

Fig. 10.2 Small spaces between teeth can be restored with back-to-back occlusal rests. Thus, reestablishing occlusion and preventing food impaction can be provided

undercut, sharp edges, and angles and should remain in enamel boundaries. There are three major forms of the rests.

10.3.1 Occlusal Rests

The form of an occlusal rest should be a round, triangular shape from the occlusal view. Its base should be at the marginal ridge and its apex should extend toward the center of the tooth. The floor of the rest seat should be spoon shaped from the sagittal view. The deepest part of an occlusal rest seat should be located near the center of the mesial or distal fossa. The size of the rest should be 1.0–1.5 mm with the tapering center of the tooth measuring 0.5 mm. If the rest does not have a sufficient bulk over the marginal ridge, which is the most critical dimension, rest fractures may occur. The recommended size of an occlusal rest is one-third to one-half the mesiodistal diameter of the abutment and approximately one-half the buccolingual width of the tooth measured between the cusp tips (Figs. 10.3 and 10.4).

The angle formed by the floor of the rest and the minor connector should be less than 90° so that the transmitted occlusal forces can be directed along the vertical axis of the tooth. If the angle is greater than 90°, the prosthesis can slip away from the abutment teeth. The appropriate angle can be achieved by preparing a spoon-shaped rest seat to avoid excess inclination, which is not recommended (Fig. 10.4).

Diamond burs with rounded ends and tapering sides can be used to prepare the rest seats (Fig. 10.5). Using a round-shaped bur may cause a rest seat with sharp edge or undercut.

Long box rests, which extend for more than half the mesiodistal width of a tooth, are used almost exclusively for the rotational path RPDs. This rest seat preparation is described in Chap. 12 (Fig. 12.14).

Onlay/overlay rests can be used on the tilted or infraoccluded teeth to restore occlusion or can be used for reestablishing occlusal vertical dimension and maximal intercuspal position in overlay removable partial dentures. This process requires minimal preparation, including

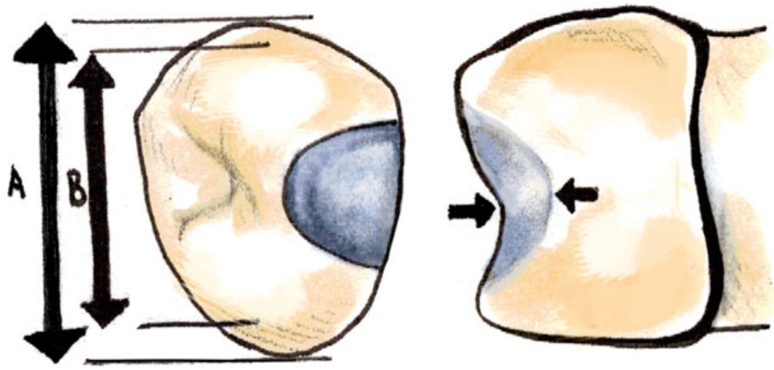

Fig. 10.3 *Left*: An occlusal rest size should be approximately A/3 or B/2. (*A*) Greatest buccolingual width. (*B*) The measurement between the cusp tips. *Right*: The depth of the occlusal rest should be 1–1.5 mm

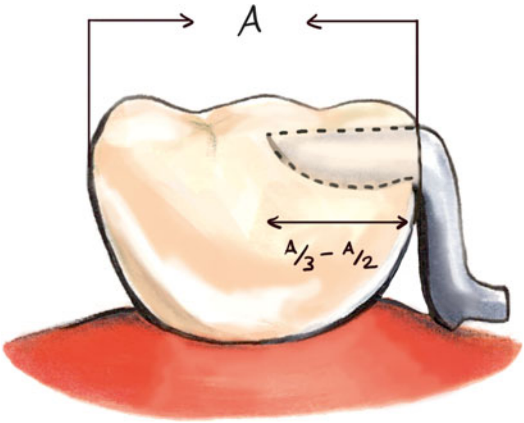

Fig. 10.4 A spoon-shaped occlusal rest should cover half or one-third of the mesiodistal length of the abutment tooth

pits, fissures, and grooves, or no tooth preparation. Tooth preparation should include a guiding plane, especially when tilted teeth do not have enough guiding surface.

When *interproximal* (*embrasure*) *occlusal rests* are made, preparation of the rest seat extends over the occlusal embrasure of two approximating teeth. It is essential to remove sufficient tooth structure (1.5 to 2.0 mm deep and 3.0–3.5 mm wide) at the facial and lingual surfaces of the abutments and to permit the component to be shaped that the occlusion will not be altered. Otherwise, fractures of the framework may occur. The contact between the teeth should be preserved to avoid tooth migration (Fig. 10.6).

A diamond bur with a rounded end and tapering sides is also suitable for this preparation.

10.3.2 Lingual (Cingulum) Rests

When posterior teeth are not present or available, *lingual rests* are utilized on anterior teeth, primarily on the canines. A satisfactory rest seat preparation can be made with minimal tooth reduction due to its well-developed cingulum (Fig. 10.7). If canines are missing, multiple incisors should receive rests to distribute the stress. It should be remembered that the preparation on lower anterior teeth may be risky because of the lack of thickness of their enamel.

A lingual rest seat preparation should be "V shaped" when viewed in cross section and "crescent shaped" when viewed from the occluso-lingual aspect. The correct angulation of the floor of the rest seat should be less than 90° from the proximal view (Fig. 10.7). When a preparation has been made on a maxillary canine, the average dimensions should be 2.5–3 mm mesiodistally, 2 mm labiolingually, and 1.5 mm occlusogingivally. Preparation of a cingulum rest seat is accomplished using an inverted cone bur.

The most anterior teeth, especially in the mandible, do not present suitable contours or depth of enamel for adequate preparation. Additionally it may create cleaning difficulties. When a cingulum is poorly developed, with insufficient bulk for the preparation of a cingulum rest seat, a rest seat can be made using composite resin (Fig. 10.8) and resin-bonded Cr-Co cast or laminates. Also, a new metal-ceramic restoration with lingual rest seat can be fabricated (see Chap. 7 and Fig. 7.10). Although more detailed studies are needed, long-term studies showed that the *bonded rest seats* can

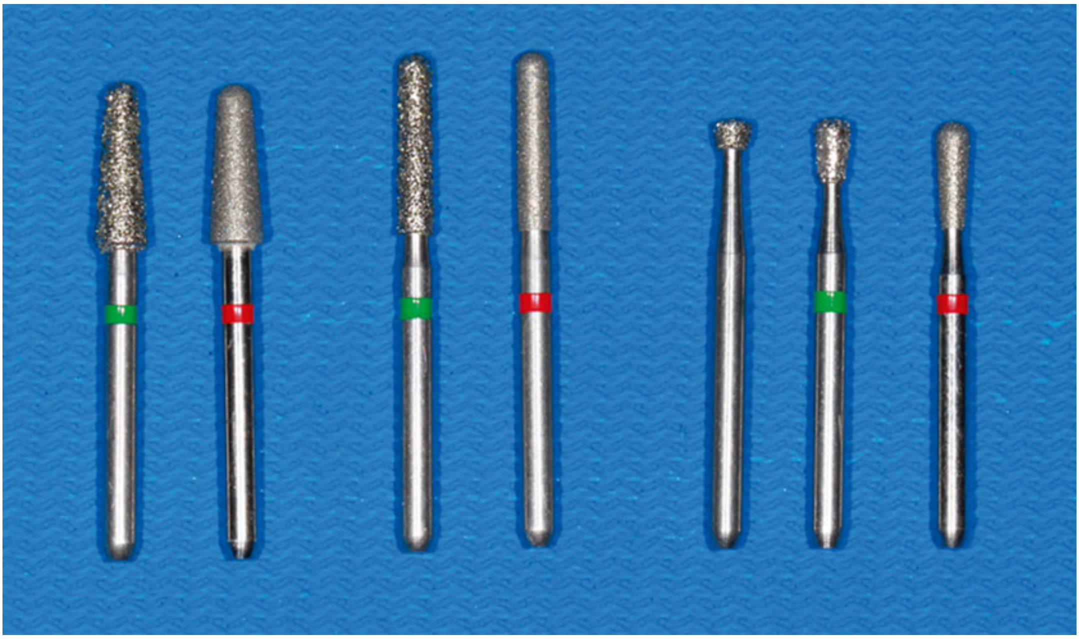

Fig. 10.5 The accessories for preparing rest seats

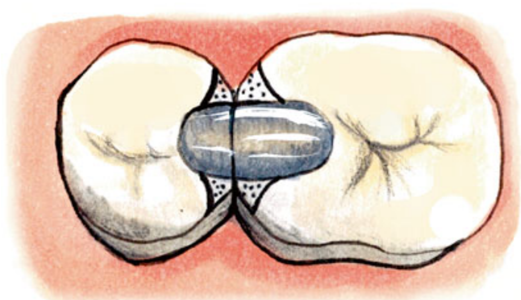

Fig. 10.6 An interproximal (embrasure) occlusal rest requires extra preparation of the dotted area. It is necessary to pay attention not to get loss of contact

provide acceptable strength and longevity without damaging the periodontal tissues of the abutment teeth. While resin-bonded metal rest seats or laminates are needed to prepare the tooth, composite resin rest seats can be fabricated by conserving the intact tooth and involving less cost. Rest seats are prepared at least 3 mm from the cervical gingiva. The cervical portion of the composite resin should not be over contoured, without sharp line angles, and should be well adapted and polished. It is also suggested to provide a composite resin rest seat after delivery of the RPD. The below-mentioned procedures should be followed: (1) A small groove is prepared as the floor of the rest on lingual surface of the teeth. (2) After impression taking, rest seat is waxed above the groove on the working cast and the framework is cast. (3) After the finishing of the RPD, the composite resin is filled in the gap and cured under the occlusal force. Thus, minimal preparation of the tooth and functional fitting can be provided.

Ceramic orthodontic brackets have also been used as rest seats. It should be remembered that the removal of these brackets results in heat generation.

In some instances (such as poorly developed cingulum, lack of clearance in the opposing teeth), *round rest seats*, which are spoon shaped like an occlusal rest seat, may be used. A reduction of the mesial marginal ridge is necessary to complete the preparation. Diamond burs with a rounded end and a tapering side, which match the tooth size, can be used to prepare the round lingual rest seats.

10.3.3 Incisal Rests

Incisal rests are less desirable than lingual rests, both aesthetically and mechanically. Whenever possible, a lingual rest seat on the natural tooth or

Fig. 10.7 A cingulum rest seat from lingual and sagittal view. The apex of the lingual rest preparation should be directed incisally

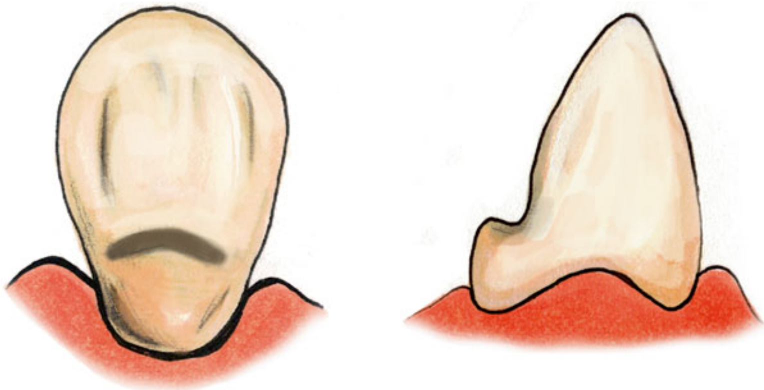

Fig. 10.8 A composite resin rest seat can be prepared when an anterior tooth has a cingulum with inadequate bulk for preparation

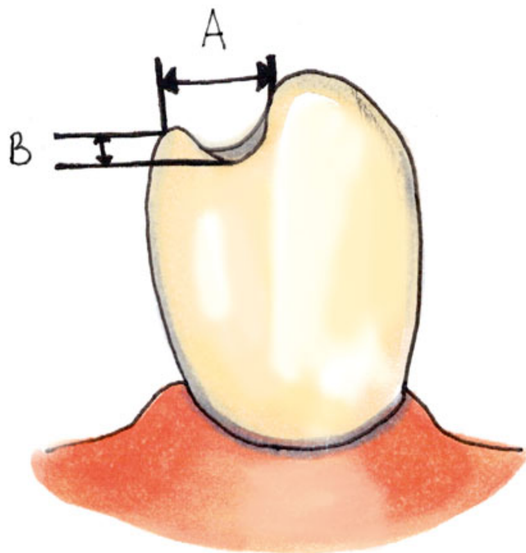

Fig. 10.9 "V"-shaped incisal rest seat dimensions should be approximately 2.5 mm mesiodistally (*A*) and 1.5 mm occlusogingivally (*B*)

composite/cast/laminate rest seats should be preferred instead of an incisal rest. A crown restoration with a lingual rest seat also can be used when it is indicated.

Incisal rest seat preparation should be "V" shaped, placed on the mesial or distal incisal angle, and its deepest portion should be toward the center of the tooth. An incisal rest seat size should be approximately 2.5 mm mesiodistally and 1.5 mm occlusogingivally. The apex of the "V" should be rounded. An incisal rest seat has two parts slightly on the facial surface and a shallow one on the lingual surface (Fig. 10.9).

A silicone-based registration material or wax can be used to measure and verify the depth of the rest seat preparation (see Chap. 7, Fig. 7.9). This procedure is also useful for detecting whether there is an undercut or not. After finishing rest seat preparations, all sharp line angles and corners should be rounded and polished. Polishing is accomplished using a carborundum-impregnated rubber wheel or a low-speed hand piece. Fluoride should be applied after the first alginate impression because some fluoride substitutes and irreversible hydrocolloids may be incompatible.

When a metal-ceramic restoration with a rest seat has been fabricated, the rest seat should be on the metal surface and placed at least 1 mm away from the metal-ceramic junction. Although the fabrication of all-ceramic crowns for RPDs with rest seats and guide planes has been described in the literature, there are still no long-term studies. When placing rest on a large amalgam restoration, possible complications should be considered and patient's consent might be taken.

Fig. 10.10 In distal extension removable partial dentures, mesial rest is recommended. But a distal rest can be used in the presence of an abutment tooth being rotated or having large restoration and a heavy centric contact on the mesial

It has been shown that the pressure distribution under the distal extension base is affected by occlusal rest localization and the RPD design. *Rest localization* varies in different, partially edentulous cases. In Kennedy I and II cases, mesial rest is preferred (Fig. 10.10). But in some cases (such as when abutment teeth are rotated and have a large restoration or a heavy centric contact on the mesial), a distal rest in a suitable prepared rest seat can be used. Long guiding planes with distal rests should not be used to avoid potential torquing. In Kennedy III and IV cases, rests are placed adjacent to the edentulous space.

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11 Direct and Indirect Retainers

Canan Bural and Onur Geckili

11.1 Definitions

Clasp The component of the clasp assembly that engages a portion of the tooth surface and either enters an undercut for retention or remains entirely above the height of contour to act as a reciprocating element. Generally it is used to stabilize and retain a removable dental prosthesis.

Clasp assembly The part of a removable dental prosthesis that acts as a direct retainer and/or stabilizer for a prosthesis by partially encompassing or contacting an abutment tooth—usage: components of the clasp assembly include the clasp; the reciprocal clasp; the cingulum, incisal, or occlusal rest; and the minor connector.

Direct retainer That component of a partial removable dental prosthesis used to retain and prevent dislodgment, consisting of a clasp assembly or precision attachment.

Height of contour A line encircling a tooth and designating its greatest circumference at a selected axial position determined by a dental surveyor; a line encircling a body designating its greatest circumference in a specified plane.

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Indirect retainer The component of a partial removable dental prosthesis that assists the direct retainer(s) in preventing displacement of the distal extension denture base by functioning through lever action on the opposite side of the fulcrum line when the denture base moves away from the tissues in pure rotation around the fulcrum line.

Indirect retention The effect achieved by one or more indirect retainers of a partial removable denture prosthesis that reduces the tendency for a denture base to move in an occlusal direction or rotate about the fulcrum line.

Infrabulge That portion of the crown of a tooth apical to the survey line.

Infrabulge clasp A removable partial denture retentive clasp that approaches the retentive undercut from a cervical or infrabulge direction.

Reciprocation The mechanism by which lateral forces generated by a retentive clasp passing over a height of contour are counterbalanced by a reciprocal clasp passing along a reciprocal guiding plane.

Reciprocal clasp A component of the clasp assembly specifically designed to provide reciprocation by engaging a reciprocal guiding plane; it contacts the action of the clasp during removal and insertion of a partial removable dental prosthesis.

RPI Acronym for rest, proximal plate, and I-bar; the clasp components of one type of partial removable dental prosthesis clasp assembly.

O. Şakar (ed.), *Removable Partial Dentures: A Practitioners' Manual*,
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Suprabulge That portion of a tooth or crown that converges toward the occlusal surface, i.e., above the height of contour.

Suprabulge clasp Any partial removable dental prosthesis retentive clasp that approaches the retentive undercut from an occlusal or suprabulge direction.

Survey line A line produced on a cast by a surveyor marking the greatest prominence of contour in relation to the planned path of placement of a restoration.

11.2 Direct Retainers

The components of an RPD that resist forces to dislodge the prosthesis from the tissues or abutment teeth are called direct retainers. Direct retainers may be classified as follows:

1. Intracoronal
   A. Precision attachments
   B. Semiprecision attachments
2. Extracoronal
   A. Retentive clasp assemblies
      (a) Suprabulge
      (b) Infrabulge
   B. Attachments

11.2.1 Retentive Clasp Assemblies

The clasp assemblies act as the direct retainers of the RPDs without precision attachments. Retentive clasp assemblies denote the most usual method for extracoronal direct retention and composed of the following parts:

1. *Rest*: The rigid extension of an RPD that contacts the occlusal surface, incisal edge, or cingulum of a tooth or restoration and the occlusal surface, incisal edge, or cingulum of which may have been prepared to receive it.
2. *Retentive arm*: The portion of the clasp assembly that lies apical to the height of contour of the abutment tooth when the RPD is fully seated. Two types of retentive arms are present: suprabulge (Fig. 11.1) and infrabulge retentive arms (Fig. 11.2).
3. *Reciprocal element*: Every retentive clasp arm should be opposed by a reciprocal element capable of resisting pressures exerted by the retentive arm during insertion and removal of the RPD. When the retentive arm passes over the height of contour, the arm presents a small amount of flexure, and this may cause lateral stress on the abutment tooth and should be neutralized by a rigid reciprocal element placed on the tooth surface opposite the retentive arm. Reciprocal element may be a clasp, a combination of mesial and distal minor connectors, or a lingual plate. Reciprocal elements should be located at the junction of the gingival and middle thirds of the abutment tooth (see Chap. 7).
4. *Body*: The rigid part of the clasp assembly joins the rest and the shoulders of the clasp to the minor connector.
5. *Minor connector*: This rigid component joins the body of the clasp assembly to the remainder of the framework (see Chap. 9).

A proper clasp assembly is required to provide the following:

1. Retention
2. Support
3. Stability
4. Reciprocation
5. Encirclement
6. Passivity

1. *Retention*
   Retention is the capability of an RPD to resist vertical dislodging forces during function and probably the most important responsibility of a clasp assembly. The dislodging forces may arise from the action of adherent foods or the gravity acting against a maxillary RPD. The retentive arms that are located in undercuts of the abutments provide retention, and this is called the primary retention (Fig. 11.3). Secondary retention is delivered by the close

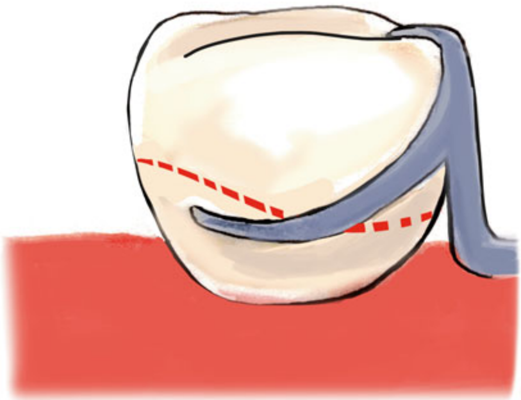

Fig. 11.1 Suprabulge retentive arm arising from the occlusal surface of the abutment tooth and reaching the undercut area

Fig. 11.2 Infrabulge retentive arm arising from the gingival surface of the abutment tooth and reaching the undercut area

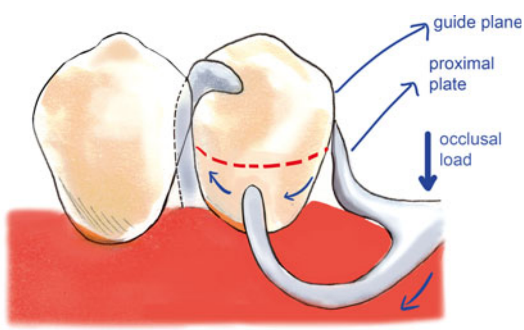

Fig. 11.3 The retentive arms that are located in undercuts on the abutments provide retention, and this is called the primary retention. Secondary retention is delivered by the close relationship of the guiding planes, proximal plates, and denture bases with minor connectors and of the major connectors with underlying tissues as the RPDs are subjected to occlusal loads

relationship of the guiding planes and denture bases with minor connectors and of the major connectors with underlying tissues (Fig. 11.3).

2. *Support*
   Support is the ability of an RPD to resist vertical seating forces. Vertical seating forces are the forces acting on the RPDs toward the gingival direction during chewing or seating the RPDs and provided mainly by the rests.
3. *Stability*
   Stability is the resistance of an RPD to horizontal forces and maintained by reciprocal elements and minor connectors.
4. *Reciprocation*
   When the retentive clasp passes over the height of contour of the abutment tooth, reciprocation of a clasp assembly prevents the lateral displacement of the abutment. This is probably one of the most important functions of a clasp assembly because it counteracts the periodontal harm and eventually the loss of the abutment teeth. Unlike the retentive arm, reciprocal elements touch the abutments at or above the height of contours in order to permit simultaneous contact of the retentive and the reciprocal elements during insertion and removal of the RPDs (Fig. 11.4). The reciprocal arm should touch the tooth at the same time with the retentive arm to avoid the lateral displacement problems.
5. *Encirclement*
   Encirclement is the specific feature of the clasp assembly to prevent horizontal movement of the abutment tooth. The clasp assembly must engage the tooth more than 180° with a direct contact (Fig. 11.5). This engagement may be in the type of continuous contact or discontinuous tooth contact in three areas as the occlusal rest and retentive and reciprocal clasp areas. Insufficient encirclement may cause tooth movement away from the clasp assembly during functional movement of the RPD.
6. *Passivity*
   When the RPD is completely seated, the clasp assembly should be passive and should not exert any force to the abutment tooth. This is called the passivity function of the clasp assembly and is very important for the periodontal health of

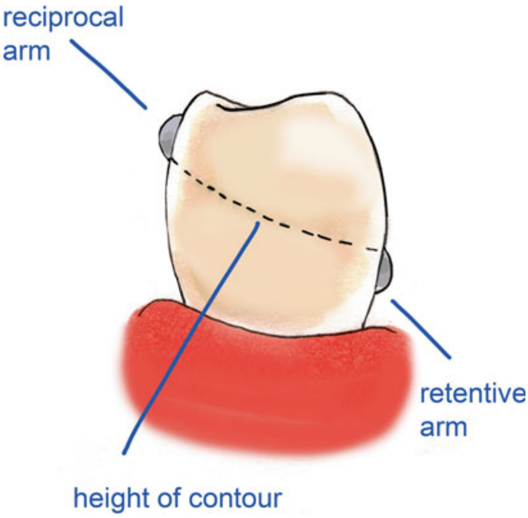

Fig. 11.4 Reciprocal elements touch the abutments at or above the height of contours in order to permit simultaneous contact of the retentive and the reciprocal elements during insertion and removal of the RPDs

Fig. 11.5 The clasp assembly must engage the tooth more than 180° with a direct contact, and this is called encirclement

the abutment teeth. The retentive arm should be active only when the dislodging forces are applied to the RPDs. When no force is present, the retentive arm should be passive to prevent nonaxial forces to the abutments.

11.2.2 Factors Affecting the Amount of Retention of a Clasp Assembly

The amount of retention provided by a clasp assembly is based on the following factors:

1. *Angle of convergence cervical to the height of contour*: Location of the retentive arm relative to the height of contour is very important for the retentive capabilities of the clasp assembly. The abutment tooth should have an angle of convergence cervical to the height of contour to be retentive (Fig. 11.6). The angle of convergence in relation to the path of insertion when the cast is surveyed is vital for the appropriate position of the clasps (see Chap. 14). If the angle of convergence is not favorable for a particular path of placement under consideration, a different path of placement should be provided, maintaining the suitable angle of convergence.
2. *Flexibility of the clasp arm*: The amount of retention depends on the flexibility of a clasp arm, and this is influenced by the following factors:
   (a) *Length*: Increasing the length of the clasp arm increases the flexibility. Flexibility of the clasp is directly proportional to the cube of its length if all other factors are equal. Clasp length is measured from the point where the taper begins. Using tapered retentive arms instead of straight ones increases the length.
   (b) *Diameter*: Cube of the thickness of the clasp arm is inversely proportional to its flexibility if all other factors are equal. The retentive clasp arm should have a uniform taper from the beginning of the body to its tip. So the average diameter will be between its origin and its terminal end. If the taper is not uniform, a point of flexure and consequently a point of weakness will happen at the narrowed part of the clasp. Therefore, the uniform taper of the retentive clasp is essential. To accomplish the ultimate uniform taper for a clasp arm to be flexible, its cross-sectional shoulder dimension should be twice the terminus.
   (c) *Cross-sectional form*: Clasps with round forms are more flexible than clasps with half round forms. Round forms are flexible in any direction, whereas in half round forms, flexibility is limited to only one direction. But most cast clasps are half

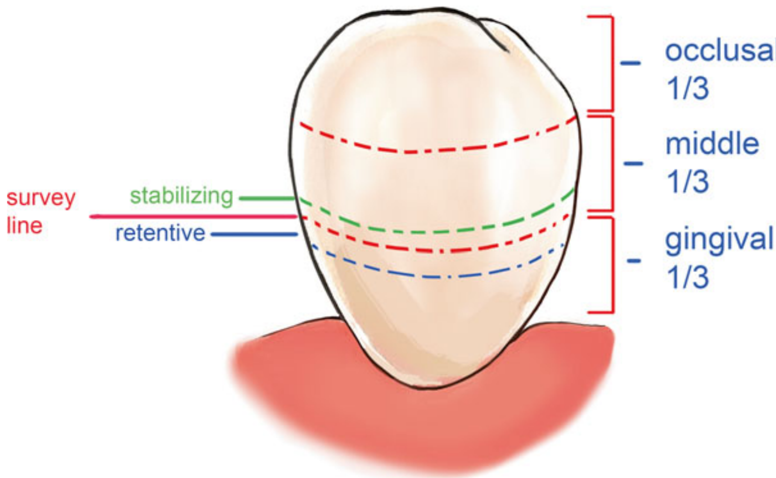

Fig. 11.6 The abutment tooth surface is divided into three according to the survey line as occlusal, middle, and gingival 1/3. Location of the retentive arm relative to the height of contour is very important for the retentive capabilities of the clasp assembly. The abutment tooth should have an angle of convergence cervical to the height of contour to be retentive

round because it is very difficult to cast and polish a round form clasp. Therefore, it is more achievable to use half round clasps with tooth-supported RPDs because in distal extension RPDs, clasps should be flexible while insertion, removable, and function of the prosthesis.

(d) *Material*: Alloys with lower elastic moduli show more flexibility. Cast gold clasps are more flexible than the frequently used cast chromium-cobalt clasps, but they are quite expensive. Therefore, it is much more reasonable for the practitioners to use wrought-wire clasps when more flexibility is needed rather than gold clasps.

11.2.3 Types of Clasp Assemblies

According to the definition of DeVan, the portion of an abutment that converges toward the occlusal or incisal surface is called the suprabulge aspect, whereas the portion of the clinical crown that converges apically is called the infrabulge aspect of the abutment.

After the introduction of two terms as infrabulge and suprabulge by DeVan, RPD clasps have been classified into two main categories:

1. Circumferential (suprabulge) clasps
2. Bar (infrabulge) clasps

11.2.3.1 Circumferential (Suprabulge) Clasps

Circumferential clasps approach the desired undercut area from the occlusal direction. They may also be called occlusally approaching clasps. Dr Polk E. Akers has introduced and standardized the method of one-piece cast RPD with suprabulge clasps, and therefore these clasps are often referred to as *Akers clasps*.

The cast circumferential clasp is the most commonly used clasp of all types. It is simple and easily constructed and repaired. Because of its retentive and stabilizing ability, it is commonly chosen for tooth-supported RPDs. For the tooth-supported RPDs, cast circumferential clasps may be replaced with bar clasps only if the aesthetics is concerned or the undercut is approached better with an infrabulge system.

Disadvantages

The following may be considered as the disadvantages of the cast circumferential clasps:

1. Not aesthetic as compared with the bar clasps especially in the mandibular arch since more metal display is present.
2. Covers a large amount of tooth surface that can cause caries or enamel decalcification if accurate oral hygiene is not maintained.
3. Its retention cannot be easily adjusted like the other cast clasp types because of the half-rounded form.

Design Principles

It has a supporting occlusal rest and a buccal retentive and a lingual reciprocating arm encircling the abutment tooth more than 180° (Fig. 11.7). The retentive arm approaches from the occlusal part, passes the height of contour, and enters the undercut area of the abutment tooth. Only the apical part of the retentive arm should engage the desired undercut, and the retentive arm should be long enough to ensure the desired flexibility. The retentive clasp arm should not be located too close to the gingival margin. The reciprocal arm may be located at or slightly above the height of contour on the lingual side of the tooth and should prevent lateral displacement of the abutment (Fig. 11.7).

A wide variety of circumferential clasp types are available, but the less complex ones should be chosen for simplicity. The following are the cast circumferential clasp types:

1. *Simple circlet clasp*: It is a simple and widely used clasp and the clasp of choice for tooth-supported RPDs where mesiobuccal undercut is present (Fig. 11.8). Since the simple circlet clasp totally achieves the design requirements of support, stability, reciprocation, encirclement, and passivity, it is considered superior to the other designs of equal capabilities.
2. *Reverse circlet clasp*
   The simple circlet design may also be used reversely and called reverse circlet clasp. This design may be used when undercuts are present near the edentulous space (Fig. 11.9). Since the rest is located on the mesial side of the abutment and the clasp is projected from the mesial to the distal side, stresses are less transmitted to the abutments. This may be regarded as an advantage of the reverse circlet clasp, and it may be used in Kennedy Class I and II situations. However, reverse circlet design has several disadvantages as listed below:
   (a) The shoulder rests on the marginal ridges of the two adjacent teeth, and this may cause premature contact areas. These may result in consequent fractures when constructed thinner than necessary.
   (b) Since no rest is present adjacent to the edentulous space to facilitate the releasing action of the retentive clasp, as the RPD moves during function, food impaction and trauma to the marginal gingiva may occur.
   (c) The design is not aesthetic and therefore should not be used especially when the abutments are maxillary canines or premolars.
   Since the shortcomings are more than the benefits of the reverse circlet clasp, it should be used with caution, and infrabulge clasps should be preferred

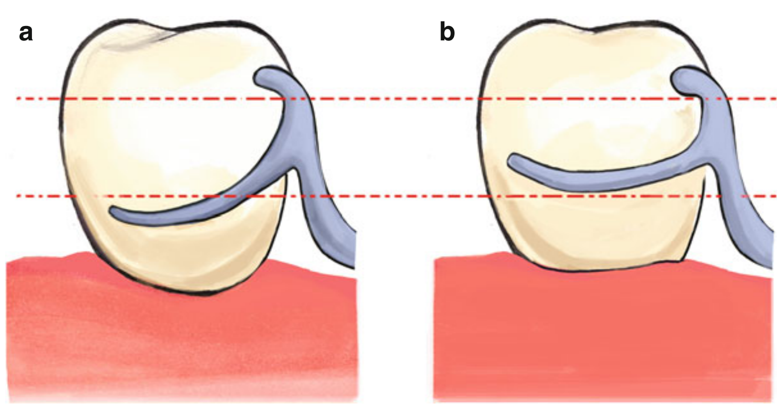

Fig. 11.7 The circumferential clasp has a supporting occlusal rest and a buccal retentive (**a**) and a lingual reciprocating arm (**b**) encircling the abutment tooth more than 180°. The retentive arm approaches from the occlusal part, passes the height of contour, and enters the undercut area of the abutment tooth (**a**). The reciprocal arm may be located at or slightly above the height of contour on the lingual side of the tooth and should prevent lateral displacement of the abutment (**b**)

when the undercut is present, adjacent to the edentulous areas. If the anatomical contour apical to the abutment disallows the use of an infrabulge clasp, reverse circlet clasps may be selected.

3. *Ring clasp*
   Ring clasps are usually used in tilted molar abutments (Fig. 11.10). A ring clasp originates mostly from the mesial rest, and it encircles nearly all of an abutment tooth and therefore should be used with caution in order not to trigger caries and demineralization. In most of the cases, an additional rest is placed on the distal surface to provide additional support. A supporting strut on the nonretentive side will prevent the clasp arm to open and close with minimum or no reciprocation and therefore may be added. Although it is an effective clasp, it should not be considered when an alternative is present because it covers extensive amount of abutment tooth structure.

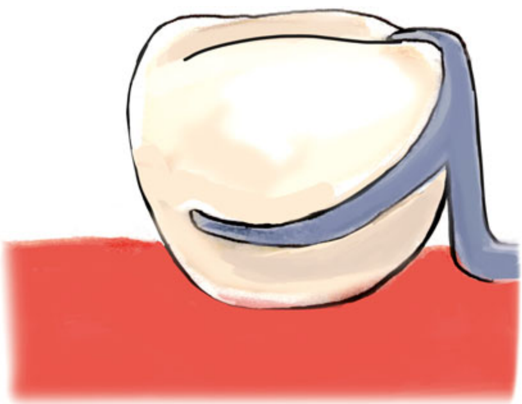

Fig. 11.8 Simple circlet clasp is a simple and widely used clasp and the clasp of choice for tooth-supported removable partial dentures where mesiobuccal undercut is present

4. *Embrasure (double Akers) clasps*
   The embrasure clasp design is most frequently used in Kennedy Class II or Class III RPDs when no modification is present to service for additional clasp designs on the opposite side of the main edentulous areas (Fig. 11.11). It consists of two circumferential clasps heading to opposite sides joining in the body. Tooth preparation is essential when using this kind of clasp design in order not to cause fatigue failure, which is a common complication (see Chap. 10). In case of inadequate tooth preparation, the use of this clasp type should be avoided.

Fig. 11.9 The reverse circlet clasp is just the opposite of simple circlet clasp and may be used when undercuts are present near the edentulous space

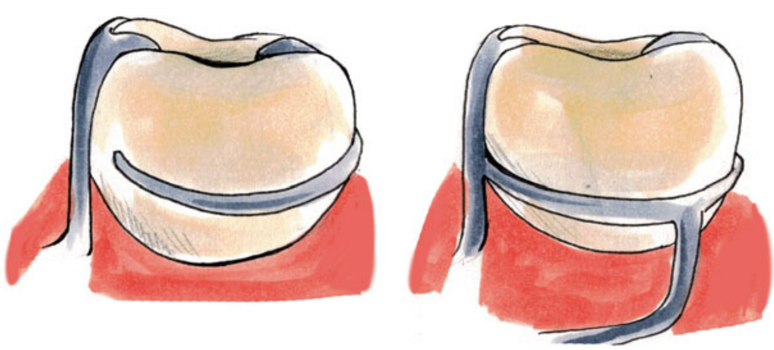

Fig. 11.10 Ring clasp originates mostly from the mesial rest and it encircles nearly all of an abutment tooth. Although it is an effective clasp, it should not be considered when an alternative is present because it covers extensive amount of abutment tooth structure

Rarely used suprabulge clasps:
In this section, the suprabulge clasp types that are not common are explained briefly.

Fig. 11.11 The embrasure clasp design consists of two circumferential clasps heading to opposite sides joining in the body

1. *Multiple clasps*
   Multiple clasp design is just a modification of the embrasure clasp to use for retaining the same kind of RPDs when the retentive areas are adjacent to each other. This design may also be used when the principal abutment tooth is periodontally compromised in tooth- or tissue-supported RPDs. The design consists of two opposing circumferential clasps joining at the terminal end of reciprocal arms (Fig. 11.12).
2. *Half-and-half clasp*
   A half-and-half clasp consists of a retentive arm on one tooth and a reciprocal arm on another (Fig. 11.13). Retentive arm arises from a minor connector and the reciprocal arm from another minor connector with or without an

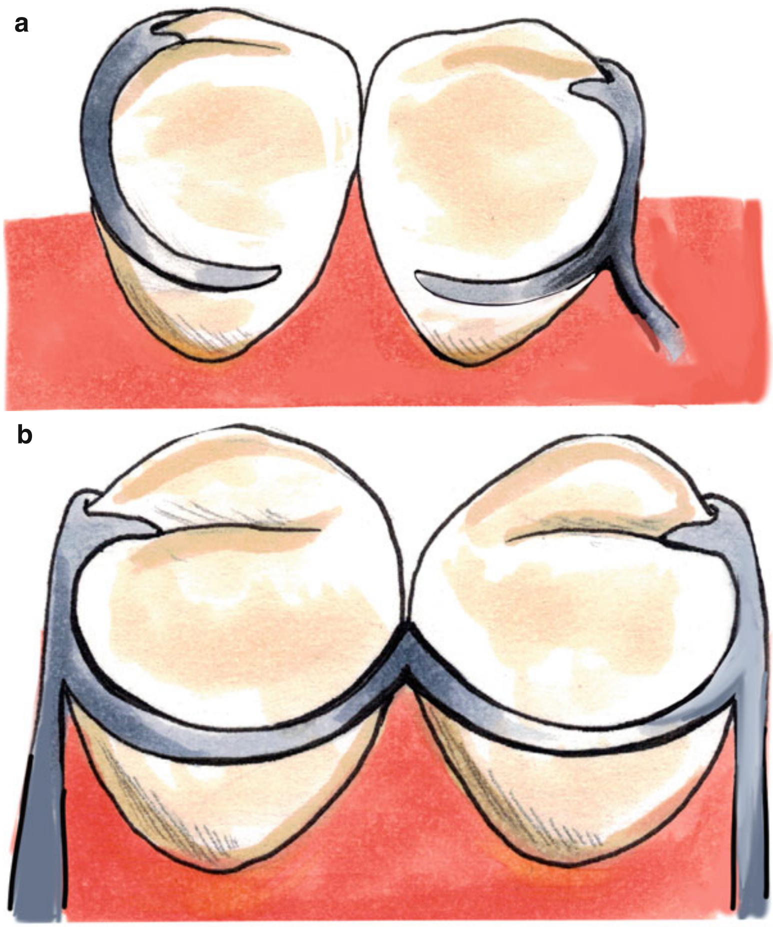

Fig. 11.12 Multiple clasp design consists of two opposing circumferential clasps (**a**) joining at the terminal end of reciprocal arms (**b**)

extra occlusal rest. It is designed for providing dual retention in unilateral RPDs.

3. *Reverse action (back action, hairpin, fish hook) clasp*
Reverse action clasps are used when the undercut is present below the starting point of the clasp (Fig. 11.14). It is not an aesthetically acceptable clasp and therefore usually not preferred in clinical practice.
4. *Onlay clasp:* This clasp type is used for both correcting the occlusion of infraoccluded abutment teeth and maintaining retention (Fig. 11.15). It is hard to fabricate and complicated for the patients, and therefore an alternative design should be preferred if possible.
5. *Equipoise clasp:* Equipoise clasp is used for obtaining aesthetic results, and it is somewhat a modification of the back-action clasp. This design is only indicated for the canines and the premolars. The retention of the clasp is maintained by the friction of the clasp components on the surfaces of the abutments. The tip of the retentive clasp arm is at the junction of the vestibular and distal surfaces of the abutments (Fig. 11.16). Since the rests are placed away from edentulous area, this clasp design can be used in Kennedy Class I and II situations and may be an alternative to RPI and RPA designs. The disadvantages of the equipoise clasp can be summarized as follows:
(a) 1 mm interproximal reduction between abutments and the adjacent teeth should be employed for gaining space for the shoulder of the clasp assembly, and this space may cause sensitivity for the abutments or the adjacent teeth. Therefore, it is much better to gain this space by making survey crown restorations and fabricating the RPD framework afterward.
(b) Poor reciprocation and lack of retention.

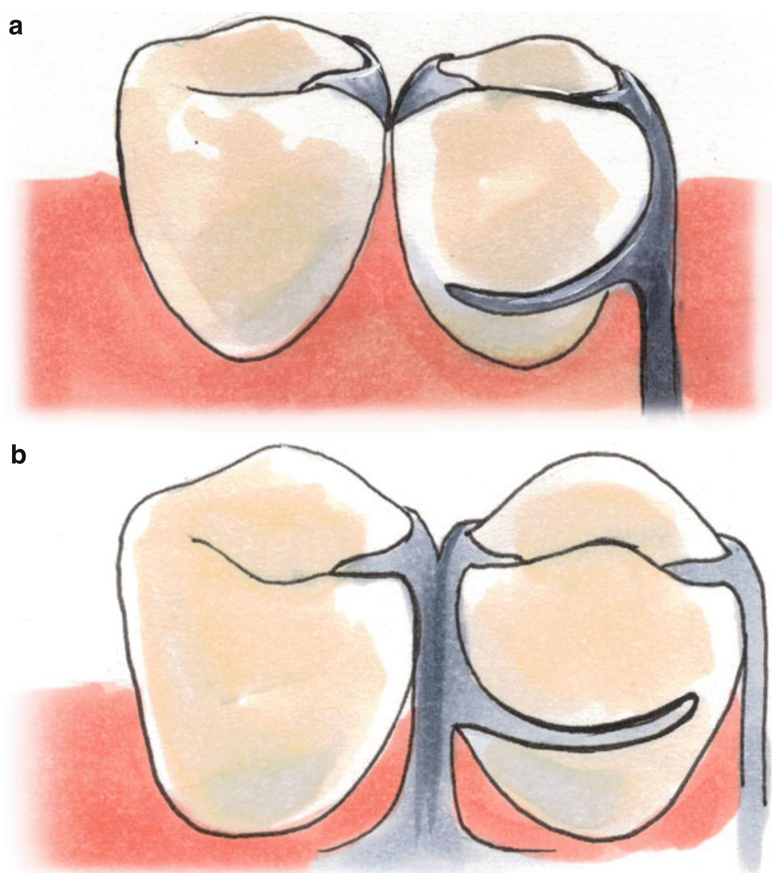

Fig. 11.13 Half-and-half clasp consists of a retentive (**a**) and a reciprocal arm (**b**) on different adjacent teeth. Retentive arm (**a**) arises from a minor connector and the reciprocal arm (**b**) from another minor connector with or without an extra occlusal rest

(c) The metal display of the shoulder between the abutment and the adjacent tooth.
(d) Processing should be performed with caution. Excess acrylic resin may surround the equipoise clasp and the clasp may lose its retentive properties, and consequent seating problems and undesirable forces to the abutments may occur.

Although this clasp design is not fully recognized by the dental literature, it has been shown that it is the most frequently used clasp system for the aesthetic capabilities in some dental schools and has been in use for over 35 years.

6. *Saddle lock hidden clasp:* The saddle lock hidden clasp is generally not recommended for aesthetic reasons. The mesial and distal proximal undercuts of natural abutments maintain retention of the design. Retentive clasp tips are located at each end of the saddle and lock the saddle to the ridge (Fig. 11.17). This hidden clasp has very limited nature of usage because of the lack of reciprocation and retentive properties. It can only be used in tooth-supported RPDs.

Fig. 11.14 A reverse action clasp may be used when the undercut is present below the starting point of the clasp

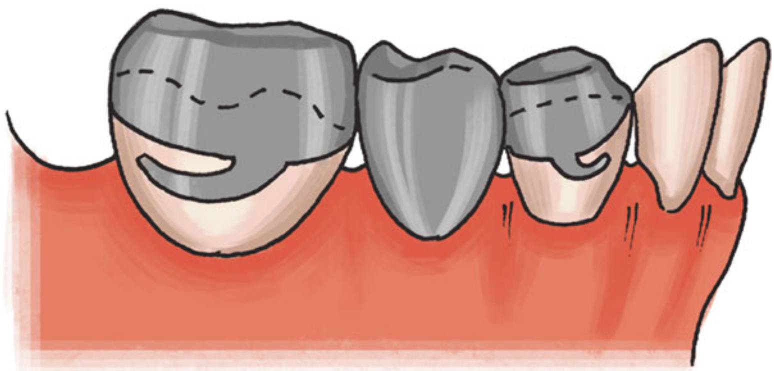

Fig. 11.15 Onlay clasp is used for both correcting the occlusion of infraoccluded abutment teeth and maintaining retention

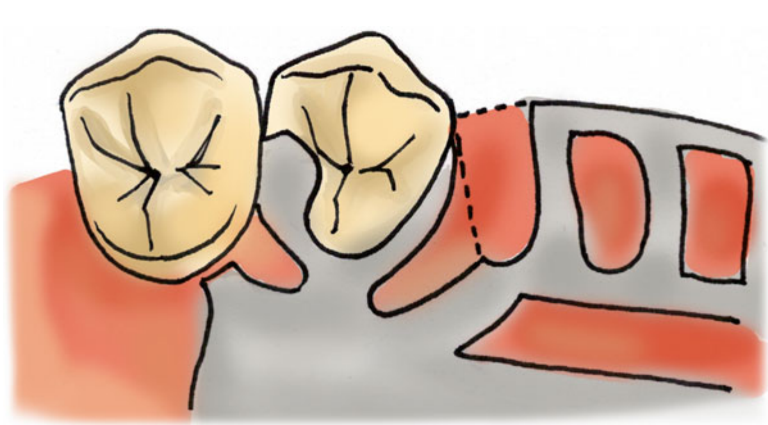

Fig. 11.16 The tip of the retentive arm of the equipoise clasp is at the junction of the vestibular and distal surfaces of the abutment

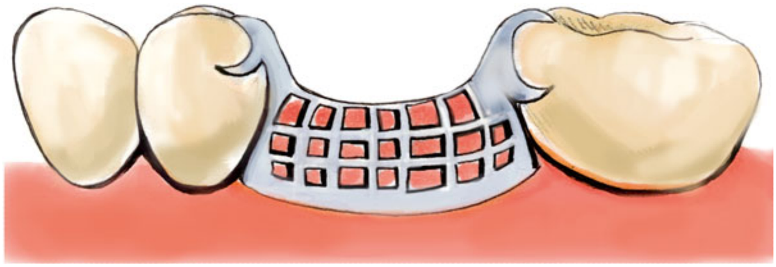

Fig. 11.17 Retentive tips of the saddle lock hidden clasp are located at each end of the saddle and locks the saddle to the ridge

7. *Flexible lingual clasp*: Flexible lingual clasp design has been recommended for mandibular abutment teeth especially for canines or premolars to overcome the unpleasant appearance of the conventional clasp types. The tooth, which will serve as an abutment for this clasp, should be restored with a crown. In the lingual surface of the crown, a wedge-shaped mesial-distal rest seat and a lingual undercut are prepared. The retentive arm engages from a mesial minor connector, and the tip is elongated as apical as possible. The reciprocal arm emerges from the proximal plate and works with the rests for reciprocation. The need of crown restorations and limitation for only mandibular abutments can be regarded as the disadvantages of the flexible lingual clasp. A differently modified lingual clasp has been proposed by Brudvik and Palacios and called lingual wire circumferential retentive clasp. The bracing arm is excluded and paralleled guide planes take its functions, and a lingual circumferential wire clasp arm provides the retention, which is not visible.

11.2.3.2 Bar (Infrabulge, Roach) Clasps

The infrabulge clasps have been given the names "bar" or "Roach" in 1930 by Dr F. Ewing Roach. Just the opposite of circumferential clasp types, bar clasps originate from the RPD frameworks and engage the undercuts from gingival direction. Roach clasps are designed mainly for Kennedy Class I and Class II situations, but they may also be used in tooth-supported RPDs. They are classified by the shape of retentive tips:

T-clasp: The T-clasp is a commonly used infrabulge clasp but regarded as the most misused clasp type with the Y-clasp because the tooth coverage areas of these clasps are rarely necessary for adequate retention. The approach arm contacts the abutment at the height of contour and separates into two horizontal projections, one of which extends toward the undercut area aimed at functioning for retention and the other over the undercut area to function for bracing and stabilization (Fig. 11.18). A T-clasp should not be used in a distal extension RPD if the only obtainable undercut is located on the mesiobuccal aspect of abutment.

The modified T-clasp: The difference of the modified T-clasp is the absence of one projection, which functions for bracing and stabilization (Fig. 11.18). The functioning properties are similar to the T-clasp. Since one of the projections is absent, this clasp type is more appropriate to use in abutment teeth with aesthetic considerations such as canines and premolars.

Y-clasp: A Y-clasp is just an alteration of the T-clasp. The only difference is that the mesial and distal projections are closer to the occlusal/incisal surface of the abutment (Fig. 11.19). A Y-clasp encircles the abutment better than the T-clasp, but it displays more aesthetic concerns.

I-clasp: An I-clasp is the bar-type clasp without any mesial and distal projections (Fig. 11.20). The design is used with a mesial rest and a distal guide and will be discussed in detail below.

11.2.4 Stress-Controlling Clasp Design for the Distal Extension RPDs

In distal extension RPDs, a Class I leverage system is formed by placing a distal rest on the abutment tooth as a fulcrum. In this type of leverage a

b

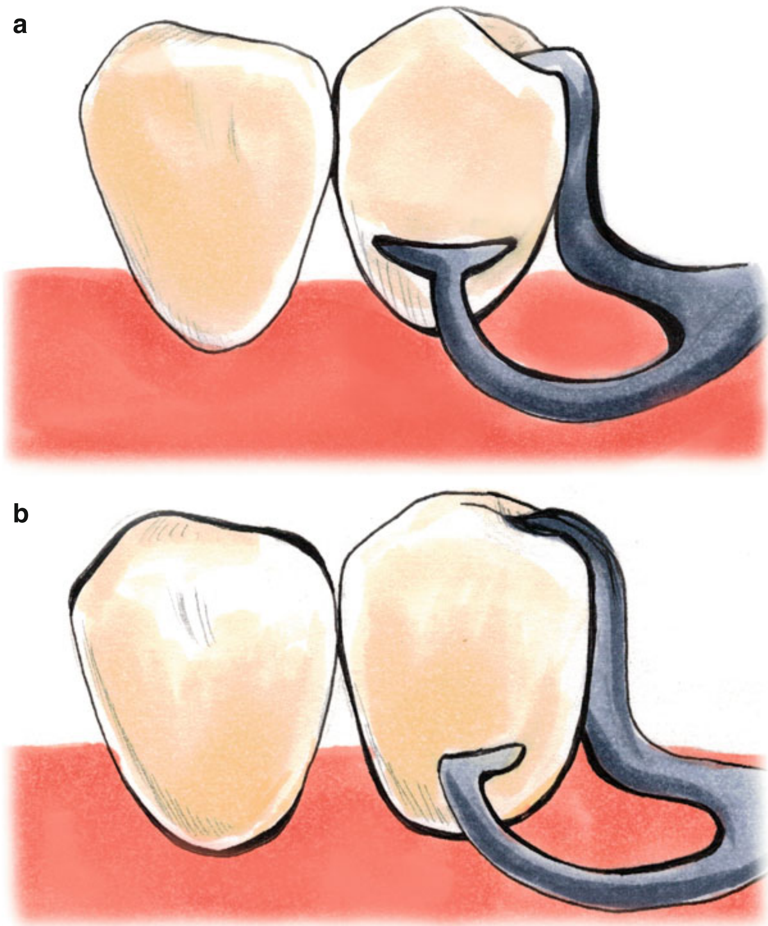

Fig. 11.18 T-clasp has an approach arm contacting the abutment at the height of contour and separating into two horizontal projections, one of which extends toward the undercut area aimed at functioning for retention and the other over the undercut area to function for bracing and stabilization (**a**), whereas the modified T-clasp has only one projection, functioning for retention (**b**)

Fig. 11.19 Y-clasp encircles the abutment better than the T-clasp, but it displays more aesthetic concerns

system, an effort arm is formed between the rest and the edentulous ridge where a resistance arm is formed between the rest and the retentive tip of the direct retainer. The effects of a Class I leverage system is discussed in Chap. 4. To convert the Class I leverage system to a Class II leverage system is practically solved by placing a mesial rest on the abutment tooth to allow the rotational

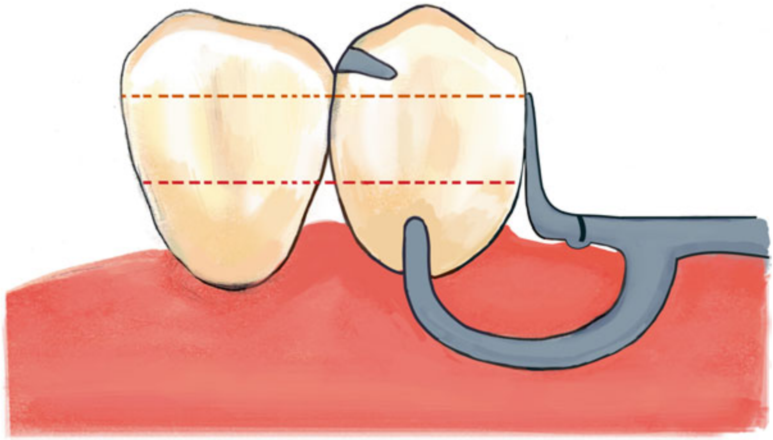

Fig. 11.20 The three main components of RPI clasp assembly with specific features. *A mesially* placed occlusal rest, *a distally placed* proximal plate, and *an* I-bar clasp. The proximal plate extends from the marginal ridge to the junction of the middle and gingival thirds of the proximal surface

tissueward movement of the RPD without excessive stress on the abutment teeth. This strategy is generally called a "mesial rest concept" in dentistry for many years. This concept mainly includes the RPI (rest, proximal plate, and I-bar clasp) and RPA (rest, proximal plate, and Akers clasp) clasp designs.

11.2.4.1 RPI Clasp Design

In distal extension base RPD, the most accepted stress-releasing design described is the RPI system. RPI clasp design is a current concept of bar clasp system, which is consisting of three main components with specific features (Fig. 11.20). All components must be properly designed and constructed to function effectively.

1. *Mesio-occlusal rest*: The rest is located on the mesio-occlusal surface of a premolar or mesiolingual surface of a canine, with the minor connector placed into the mesiolingual embrasure. The minor connector should not be in contact with the adjacent tooth to prevent wedging. The rest acts as a fulcrum point for the rotational movement.
2. *Proximal plate*: A proximal plate is prepared on a distal guiding plane on the distal surface of the abutment tooth adjacent to the edentulous site. The buccolingual width of the plate is determined by the proximal contour of the abutment tooth. The plate is approximately 1–1.5 mm thick and extends from the marginal ridge to the junction of middle and gingival thirds of the abutment tooth. The proximal plate should be designed as the thinnest in the buccal and the thickest at the lingual. The proximal plate extends lingually so that the distance between the minor connector and the proximal plate is less than the mesiodistal width of the tooth and joins the framework at a right angle (Fig. 11.21). The proximal plate in conjunction with the minor connector that supports the rest serves for stabilization and reciprocation against the force exerted by the retentive arm of the clasp during seating and removal of the RPD. The reciprocation is provided by the simultaneous contact of the proximal plate and the minor connector on the abutment tooth (Fig. 11.22). In cases where a simultaneous contact cannot be provided as may occur on the molar teeth, the retentive I-bar clasp should be positioned to engage the mesiobuccal undercut

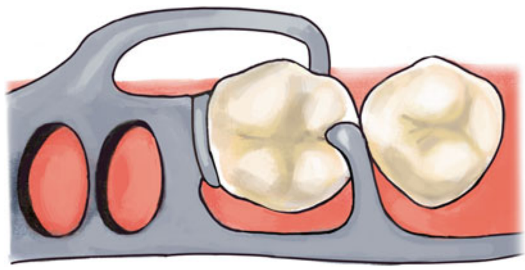

Fig. 11.21 The lingually extended proximal plate. The distance between the minor connector and the proximal plate should be designed less than the mesiodistal width of the tooth, and the proximal plate should join the framework at a right angle

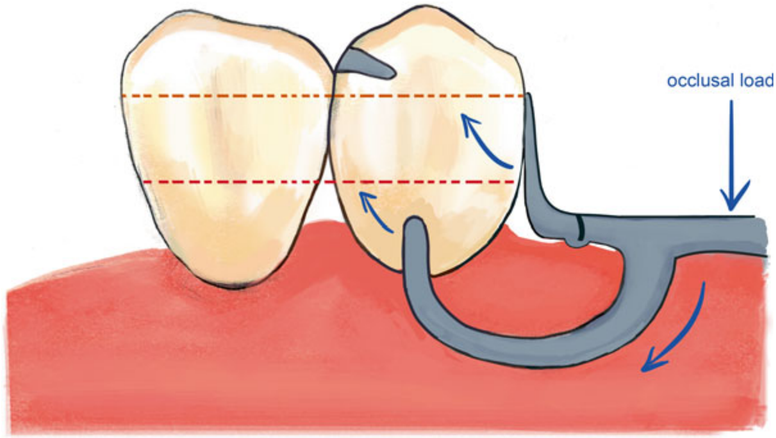

Fig. 11.22 The proximal plate serves for stabilization and reciprocation against the force exerted by the retentive arm of the clasp during seating and removal of the RPD. When an occlusal load is applied on the distal extension base, rotation around the mesial rest causes the retentive tip of the I-bar clasp to move mesially. The reciprocation is provided by the simultaneous contact of the proximal plate and the minor connector on the abutment tooth

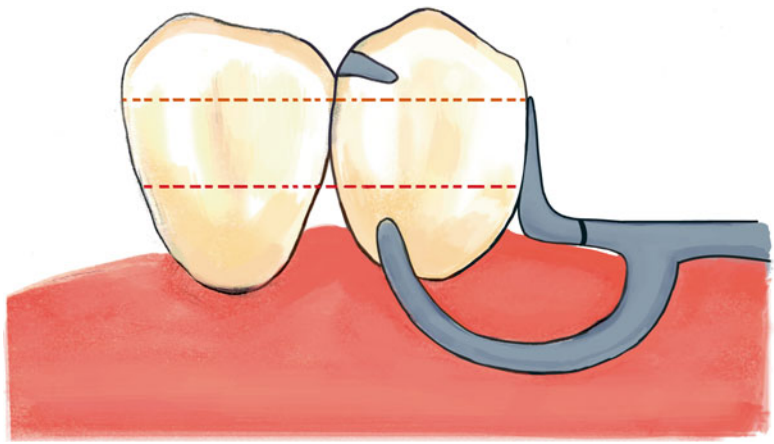

Fig. 11.23 When a simultaneous contact cannot be provided (e.g., on the molar teeth), the retentive I-bar clasp should be positioned to engage the mesiobuccal undercut to receive reciprocation

to receive reciprocation (Fig. 11.23). On narrow formed abutment tooth, such as mandibular premolars, the proximal plate should also be designed narrow, but it should be wide enough to prevent the lingual migration. The occlusal load on the extension base moves the proximal plate in a mesiogingival direction without torquing the tooth and brings the plate into tight contact with the distal surface of the tooth.

There are three approaches for the proximal plate design in relation to the contact to the guiding plane:

(a) The proximal plate extends to the entire length of the guiding plane (Fig. 11.24).
(b) The proximal plate extends from the marginal ridge to the junction of the middle and gingival thirds of the proximal surface (Fig. 11.20).
(c) The proximal plate contacts approximately 1 mm of the apical portion of the guiding plane (Fig. 11.25).

The distance between the proximal plate and the minor connector should be at least 5 mm. A physiological minimal relief is provided at the tooth-tissue junction to disengage under occlusal load (Fig. 11.26). Opening the embrasure spaces that might result in food impaction prevents the impingement of the gingivae.

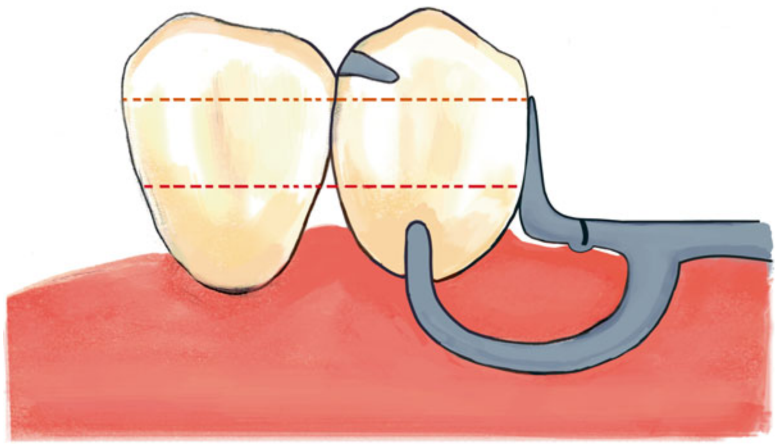

Fig. 11.24 The proximal plate extends to the entire length of the guiding plane

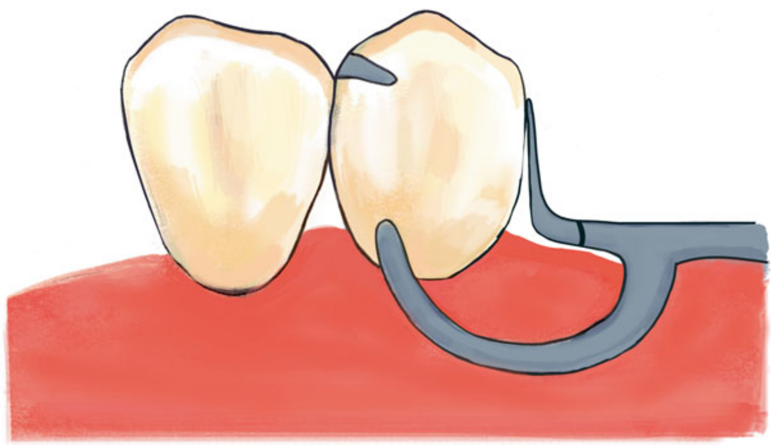

Fig. 11.25 The proximal plate contacts approximately 1 mm of apical portion of the guiding plane

3. *I-bar clasp*: the clasp is located in the gingival third of the buccal surface of the premolar and on the mesiobuccal surface of the canine engaging 0.010 in. of buccal undercut. The I-bar originates from the grid work and approaches the tooth from the gingival direction and receives its reciprocation from the proximal plate. The clasp terminus disengages from the tooth when an occlusal load is applied to the adjacent distal extension base. No contact between the approaching arm and the tooth minimizes the lateral forces. The I-bar makes a 2 mm contact with the tooth, and the bend in the I-bar should be located at least 3 mm from the gingival margin to minimize the risk of the food accumulation and to increase the flexibility of the clasp arm (Fig. 11.27). The clasp is usually cast and is placed just below the height of the contour line. The small terminus of the I-bar, minimal tooth contact, less retention, and less horizontal stability are the disadvantages of I-bar.

The location of the I-bar at the mesial is especially reasonable in symmetric distal extension base RPDs, in which the axis of rotation around the most distal abutments with mesial rests is perpendicular to the longitudinal axis of the denture base and thus creating a Class II leverage system. However, in asymmetric distal extension base RPDs the axis of rotation is shifted distally to the side of the short edentulous base. In this situation, the I-bar has a potential to move laterally with a Class I leverage effect. The solution may be the placement of the tip of the I-bar distal to the fulcrum line to minimize the potential torque.

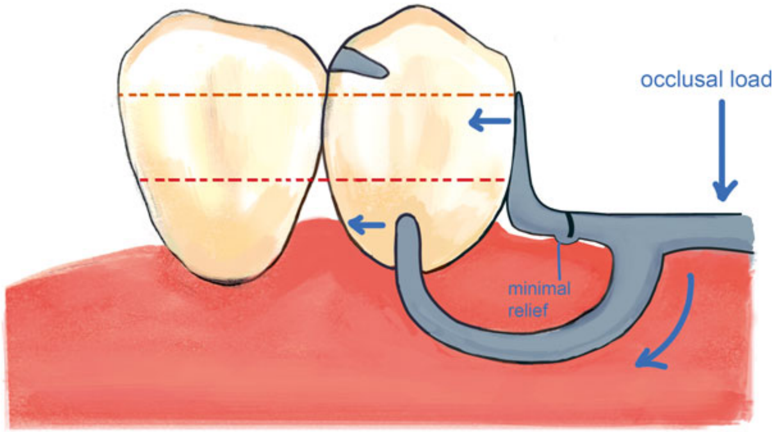

Fig. 11.26 A physiological minimal relief should be provided at the tooth-tissue junction to disengage under occlusal load. To prevent the gingival impingement, the embrasure spaces should be opened, but the space should not be too large to cause food accumulation

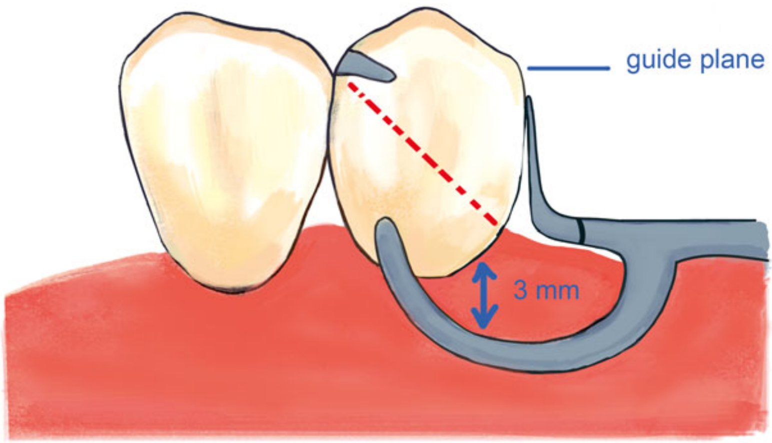

Fig. 11.27 The retentive tip makes a 2 mm contact with the tooth, and the bend should be located at least 3 mm from the gingival margin to increase the flexibility of the clasp arm and to prevent the food accumulation

In clinical practice, when two teeth are splinted, the mesial rest is placed on the anterior tooth, while the I-bar is placed on the posterior tooth. If a three-unit fixed restoration is used, the same rule is to be followed.

The RPI design meets the need of vertical support, horizontal stabilization, retention, reciprocation, and passivity. In a finite element study, compared to Akers and embrasure clasp assemblies, it was shown that RPI clasp assembly showed much lower stress concentration within the periodontal ligament and the buccal cortical bone supporting the abutment tooth, apical stress intensity distribution, distal displacement, and the widest relative area of mucosal stress transfer, suggesting a mechanical advantage. The RPI clasp contacts the tooth minimally and therefore is usually more aesthetic than the other clasp arms. In addition, another important advantage of the RPI clasp is its avoidance of contact with the lingual surface of the abutment tooth.

However, in some cases, RPI clasp assembly cannot be applied due to some contraindications and limitations:

(a) Insufficient depth of vestibule: at least 3 mm distance for the vestibule depth is required for the clasp arm to approach the tooth.
(b) Tilting of the abutment tooth. Abutment tooth tilted too much in a lingual direction and therefore no buccal undercut area or tilted too much in a buccal direction.
(c) Buccal tissue undercut: a severe buccal tissue undercut causes the clasp arm to approach the tooth too far away from the gingiva. The need of extensive relief creates risk for food accumulation under the clasp arm and the

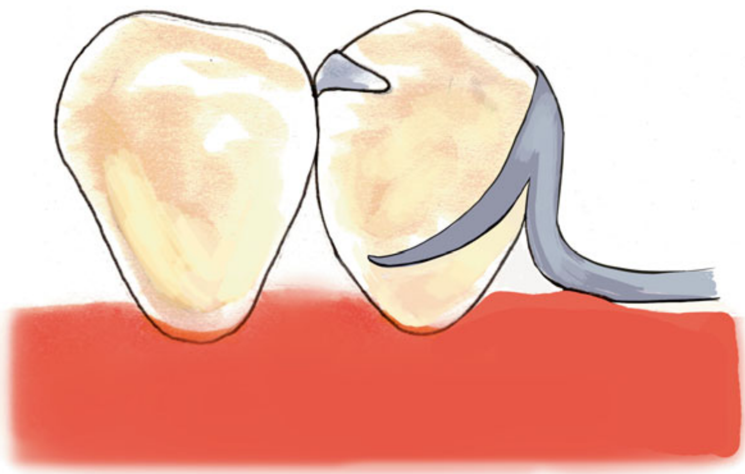

Fig. 11.28 The RPA clasp assembly. *A mesially* placed occlusal rest, *a distally placed* proximal plate, and *an* Akers clasp

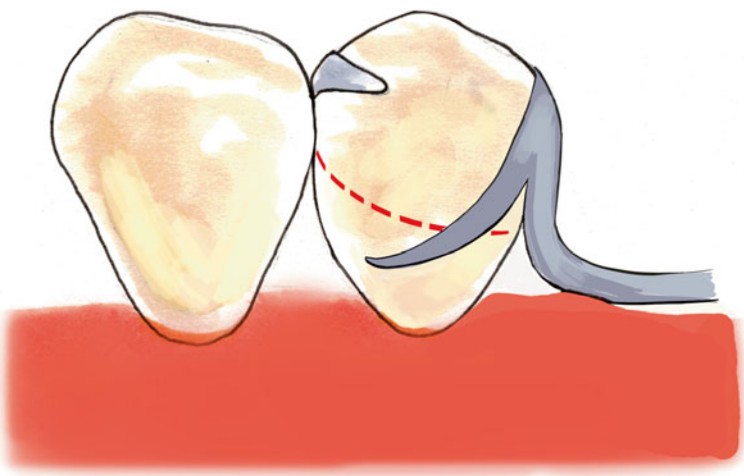

Fig. 11.29 The retentive arm of the Akers clasp in relation to the survey line should be correctly designed to ensure the success of the clasp assembly

irritation of the mucosal tissue of the cheeks and the lips.

(d) Distobuccal undercut: if only a distobuccal undercut is available.

(e) The use of lingual plate as a major connector. If there is a high floor of the mouth, then a lingual plate should be used as a major connector. The major connector should be located at least 3 and 6 mm away from the mandibular and maxillary RPD, respectively.

(f) For some patients, the manipulation of the RPI might be difficult to grasp with finger or thumbnail for seating or removal of the RPD.

(g) Smile display: in patients where a great gingival tissue is displayed, the use of I-bar might negatively affect the aesthetics.

11.2.4.2 RPA Clasp Design

The RPA clasp design was developed to overcome the contraindications and limitations with the RPI design. In this design, the mesial rest and the proximal plate features are identical to those of RPI. The only difference is the use of an Akers clasp instead of the I-bar clasp (Fig. 11.28).

Akers clasp: The undercut will vary from 0.01 to 0.02 in., depending on the size of the abutment tooth. An Akers or a circumferential clasp arises from the superior portion of the proximal plate and extends around the tooth to engage in the mesiobuccal undercut. Under occlusal load during the rotational movement, the proximal plate will move gingivally and

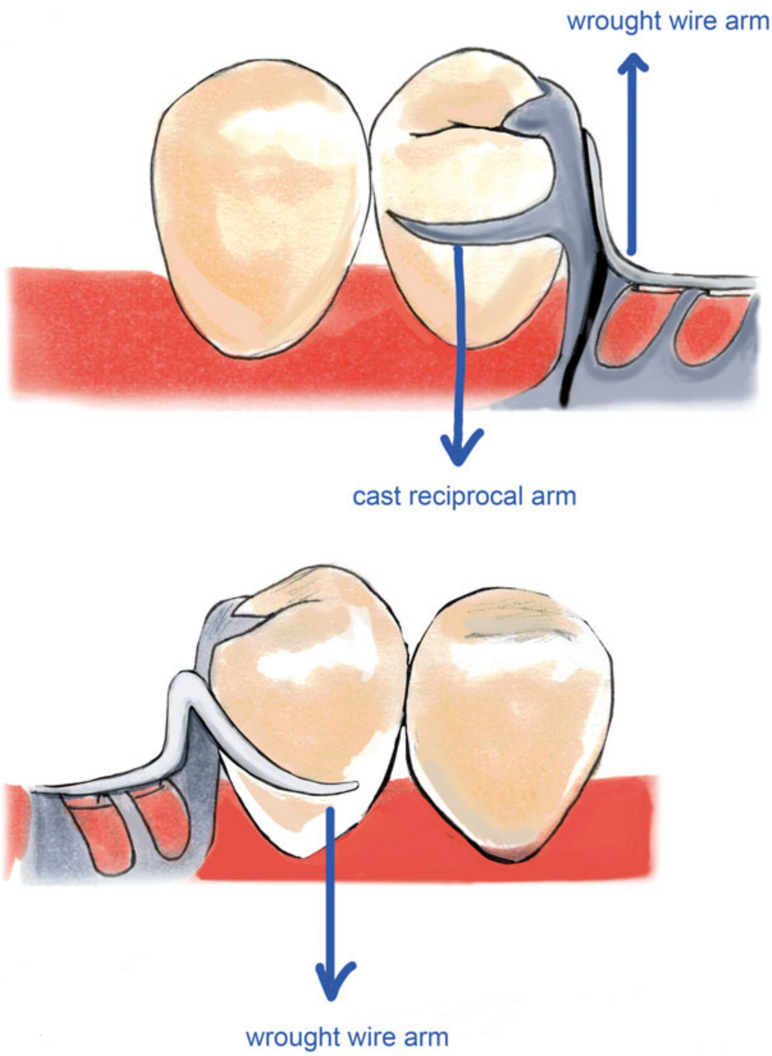

Fig. 11.30 Combination clasp: *An* occlusal rest, *a* cast reciprocal arm at the lingual side, and *a* tapered, round wrought-wire retentive clasp arm at the buccal side. The wrought wire is soldered to the cast metal framework

slightly mesially; the rigid portion of the clasp contacts the tooth along the survey line and moves gingivally and mesially, while the retentive tip of the clasp also moves gingivally and mesially. The movement of the retentive tip of the clasp occurs due to the tissue relief for this design to be successfully functioning to avoid torquing of the abutment tooth. The success of the RPA clasp assembly is dependent on the proper positioning of the Akers clasp in relation to the survey line (Fig. 11.29).

11.2.4.3 Combination Clasp

To avoid the possible negative effects of the Class I leverage system, another clinical option is to use a combination clasp, which consists of an occlusal rest, cast reciprocal arm, and a tapered, round wrought-wire retentive clasp arm that is soldered to the cast framework (Fig. 11.30). The wrought-wire retentive arm makes a line contact with the abutment tooth. This design is recommended in the following:

1. For the anterior abutment of the posterior modification space in a Class II partially edentulous arch only when a mesiobuccal undercut exists, to minimize the effects of a first-class leverage system
2. A severe buccal tissue undercut that does not permit the use of a bar clasp

3. When flexibility is required on the abutment tooth adjacent to the distal extension base
4. On periodontally compromised abutment tooth when a cast bar-type clasp is not indicated

The advantages of this clasp assembly are flexibility due to its circular cross-sectional form, adjustability when necessary, and appearance due to its round form and smaller diameter of 18 gauges. However, as disadvantages, it should be kept in mind that this clasp design needs extra steps in RPD fabrication and is easily deformed and less stabilized. This clasp system can be used even in 0.02 in. mesiobuccal undercuts due to its flexibility. These clasps may also be used in tooth-borne partial edentulous cases.

11.2.4.4 Rarely Used Infrabulge Clasps

RLS system: The RLS system uses the undercuts of the lingual surfaces of the abutments. It involves a mesio-occlusal rest, a distolingual L-bar direct retainer, and a distobuccal reciprocal element (Fig. 11.31). The clasp system uses the rationale for RPA and RPI systems. It can be used for the distal extension RPDs when no undercut is present on the facial surface of the abutments or when aesthetics would be severely compromised with the use of RPI and RPA clasps.

Twin-flex clasp (spring-clasp): The twin-flex system uses a wrought wire soldered into a channel, which is cast into the major connector. It is claimed that the clasp is flexible and therefore never produces torque to the abutments and can be used as an aesthetic alternative for distal extension RPDs. The disadvantages include increased thickness of the major connector due to the channels, inability to be repaired, and increased laboratory cost due to the complexity of the design. To overcome the toxicity associated with galvanic corrosion while soldering and the increased major connector thickness, the technique has been modified as twin-flex improved clasp. In this technique, the U-shaped wire is inserted from lingual to facial into the framework before tooth setup (Fig. 11.32). The RPD is flasked and finished afterward, and the wire is adapted to the abutment by the clinician. This improved design can be adjusted or replaced easily.

Round-rest, distal depression clasp (RRDD): The RRDD clasp has been designed for an aesthetic alternative to conventional clasp types when the abutments are maxillary incisors or

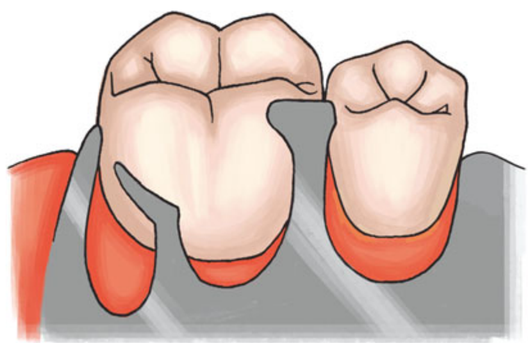

Fig. 11.31 The RLS system: *A mesio*-occlusal rest, *a* distolingual L-bar direct retainer, and *a* distobuccal reciprocal element

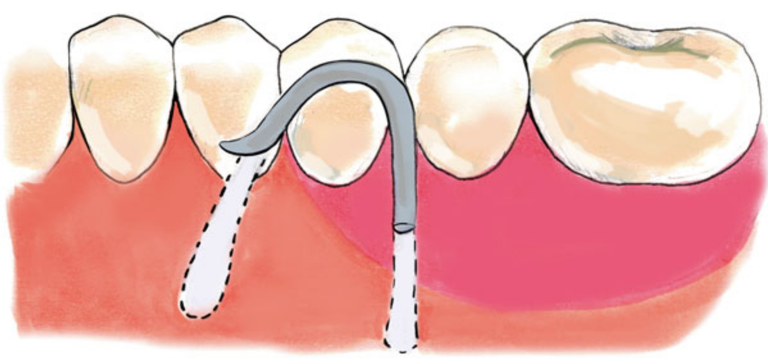

Fig. 11.32 The twin-flex system uses a wrought wire soldered into a channel, which is cast into the major connector. The U-shaped wire is inserted from lingual to facial into the framework before tooth setup

canines. It involves a round rest seat near the cingulum, a mesiolingual reciprocating plate, and a split minor connector engaging a distal depression for retention (Fig. 11.33). If the edentulous span is mesial to the abutment tooth, the system is called RRMD. The RRDD clasp lacks the encirclement of a clasp assembly; therefore, it is not recommended for distal extension RPDs. The only indication is tooth-supported maxillary RPDs when the abutments are incisors or canines.

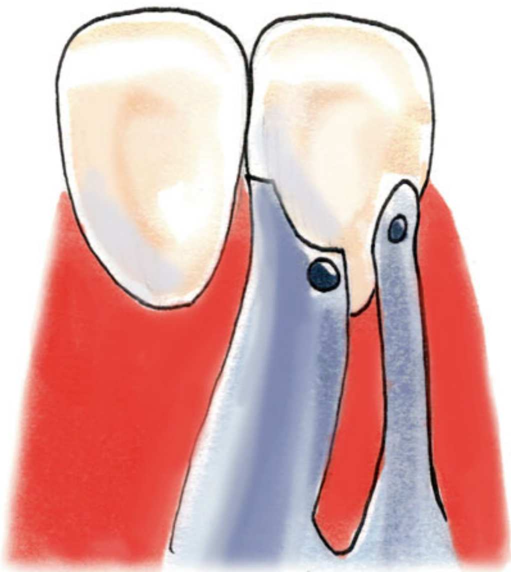

Fig. 11.33 Round-rest, distal depression clasp: *A* round-rest seat near the cingulum, *a* mesiolingual reciprocating plate, and *a* split minor connector engaging a distal depression for retention

The RPH clasp: The RPH clasp is the modification of the RPI system as mesial rest (R), proximal plate (P), and horizontal retentive arm (H-RPH) (Fig. 11.34). The retentive arm is projected horizontally, but since it touches the abutment only at its retentive tip, this clasp type is considered as an infrabulge clasp. The horizontal retentive arm may be cast half round and round or may be made up from wrought wire according to the specific situation. This clasp may be an alternative to RPI clasps where there are soft tissue undercuts, high-frenal attachments, or shallow vestibular depth.

11.3 Indirect Retainers

An indirect retainer is an auxiliary occlusal, incisal, or cingulum rest that displays accurate and definitive contact with a properly designed, horizontally oriented rest seat. All Kennedy Class I, Class II, and Class IV RPDs require effective indirect retention. During mastication, the denture rotates around the fulcrum line (Fig. 11.35) that passes through the most posterior rests, causing the denture to move away from the tissues or move tissueward. This rotational movement is described in Chap. 4. When the denture base moves away from the supporting tissues, the anterior portion of the major connector impinges upon the underlying supporting structures. This impingement may cause negative side effects such as trauma to

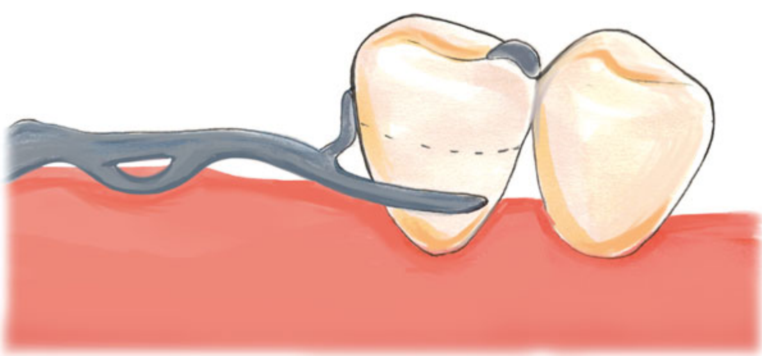

Fig. 11.34 The RPH clasp is the modification of the RPI system as mesial rest, proximal plate, and horizontal retentive arm

the soft tissue or extensive destructive forces to the supporting teeth. The movement away from the tissues can be resisted by activation of the direct retainer, the stabilizing components of the clasp assembly, and the rigid indirect retainers.

The importance of the well-designed indirect retention (rests and minor connectors) counteracts these negative side effects. Indirect retention can only be achieved when one or more rigid indirect retainers are positioned in properly prepared rest seats. To prevent displacement of an extension base away from the tissues, practically one or more indirect retainers must be positioned perpendicular to the fulcrum line as far as possible to provide the best leverage system against dislodging forces (Fig. 11.36).

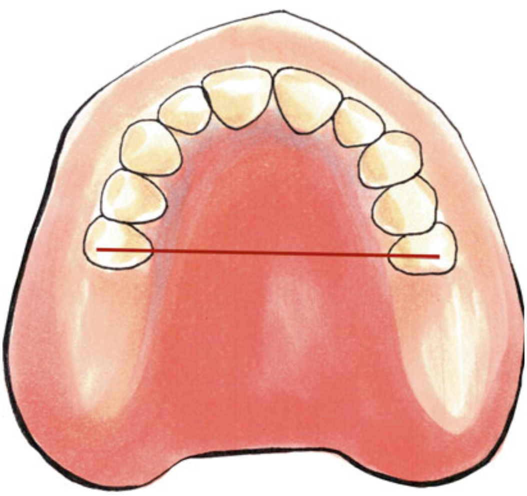

Fig. 11.35 Fulcrum line. The RPD rotates around the fulcrum line, which passes through the most posterior rests. This rotational movement causes the RPD to move away from the tissues or toward the tissue

The effectiveness of the indirect retention will be increased as the distance to the fulcrum line increases. It is also important to choose the most suitable abutment tooth to place the rests for indirect retention. Although the most effective location for indirect retention is the vicinity of an incisor tooth, rests for indirect retention are not preferred to be placed on the incisal teeth due to their lingual surface anatomy in clinical practice. For indirect retention, the most commonly used teeth are canines and premolars due to their increased periodontal support compared to incisal teeth, despite the fact that they are not as far from the fulcrum line (Fig. 11.37). In these cases, choice of two locations for indirect retention might be clinically beneficial to compensate the shorter distance to the fulcrum line. A cingulum rest is used for the purpose of indirect retention on a canine tooth and an occlusal rest for the premolar tooth to direct the forces axially. In cases where only the use of indirect retention is available with the incisor teeth, an incisal rest seat should be prepared. In these situations, it may be more aesthetically improved if crown restorations with the lingual rest seat are prepared.

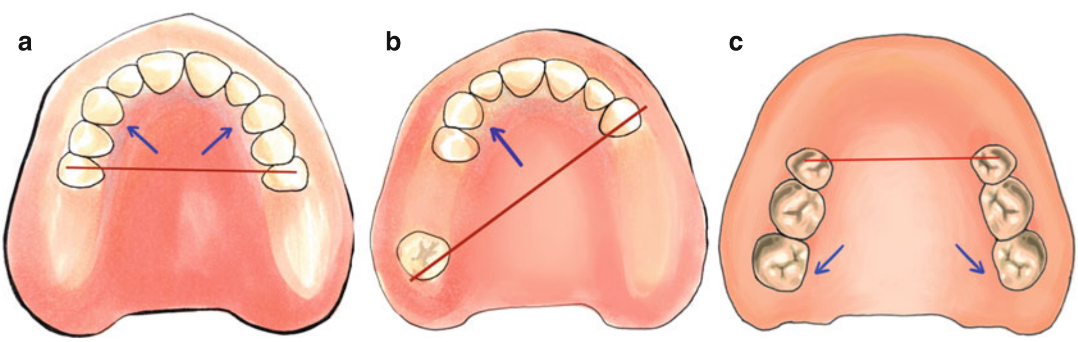

Fig. 11.36 One or more indirect retainers must be positioned perpendicular to the fulcrum line as far as possible to provide the best leverage system against dislodging forces. (**a**) In Kennedy Class I cases, (**b**) in Kennedy Class II cases, and (**c**) in Kennedy Class IV cases

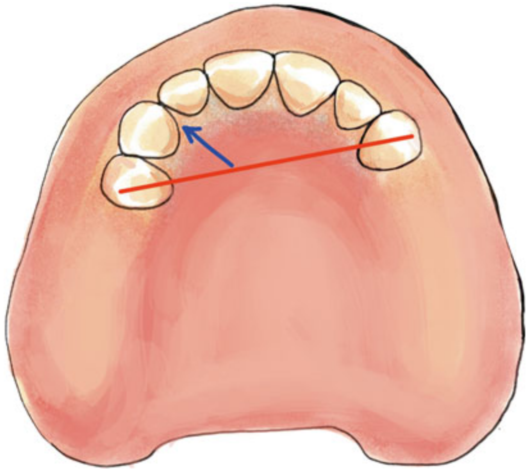

Fig. 11.37 Although it may not be as far from the fulcrum line, the most common used teeth are canines and premolars due to their increased periodontal support compared to incisal teeth

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12 Esthetic Solutions for Removable Partial Dentures

Olcay Şakar

12.1 Definitions

Thermoplastic A characteristic or property of a material that allows it to be softened by the application of heat and return to the hardened state on cooling.

Resin 1: Any of various solid or semisolid amorphous natural organic substances that usually are transparent or translucent and brown to yellow; usually formed in plant secretions; are soluble in organic solvents but not in water; are used chiefly in varnishes, inks, plastics, and medicine; and are found in many dental impression materials 2: a broad term used to describe natural or synthetic substances that form plastic materials after polymerization. They are named according to their chemical composition, physical structure, and means for activation of polymerization.

Nonmetal clasp dentures (NMCDs) It is used to refer not only to dentures that do not contain any metal elements but also to dentures that incorporate a metal rest or framework and is defined as "the general name for removable partial dentures (RPDs) using denture base resins as the denture retentive parts."

Rotational path removable partial denture (rotational path RPD) A partial removable dental prosthesis that incorporates a curved, arcuate, or variable path of placement allowing one or more of the rigid components of the framework to gain access to and engage an undercut area.

Patients' acceptance of their dentures and their satisfaction are affected by aesthetic factors. The appearance of the metal clasps in the aesthetic zone can be objectionable for many patients. To overcome the aesthetic problem, different solutions have been presented in the literature. The use of precision attachments, double-crown systems, and implants in removable partial dentures (described in part IV) can be aesthetic treatment options, but these options require tooth preparation to fabricate crown restoration and a surgical operation. As a result, the increased cost is inevitable. Different metal clasp designs presented in Chap. 11 can also be aesthetic alternatives in removable partial dentures. In this chapter, widely accepted and used other treatment alternatives, which are thermoplastic resins for nonmetal clasp dentures and rotational path removable partial denture design, are described. The advantages, disadvantages, and the basic principles in clinical usage are presented.

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12.2 Nonmetal Clasp Dentures

Thermoplastic resins are used for nonmetal clasp dentures (NMCDs). They can be used both as a denture base material (such as polyamides, polyesters, polycarbonates, polypropylenes, polyacetal resin) and as a preformed clasp (such as polyetheretherketon, polyetherketonketon, polyoxymethylene/acetal resin) for the fabrication of NMCDs. Although there are no sufficient studies related to the physical properties and clinical follow-up of all the thermoplastic materials, they are used in dental practice. Therefore, their mechanical and physical properties, as well as their clinical usage, maintenance, and complications, will be described in the light of the studies carried out up to now. Also manufacturer brands will be mentioned when presenting study results.

It should be kept in mind that the following advantages and disadvantages may vary according to material selection.

General advantages of nonmetal clasp dentures and thermoplastic resin materials

1. Aesthetic appearance of NMCDs is more satisfactory than the metal clasp dentures (Fig. 12.1a, b).
2. Wearing and fitting of NMCDs with thermoplastic base can be more suitable for patients due to the flexibility and softer surface of thermoplastic resins compared to acrylic resins.
3. Thermoplastic resins can be used in patients who have an allergy to metal.
4. Thermoplastic resins have hygienic advantages due to their low water absorption and solubility.
5. Thermoplastic resins contain very little or almost no free monomer.
6. Creep resistance and fatigue endurance of thermoplastic materials are very high, and they are also resistant to wear and solvent materials.
7. Although the flexural strength and modulus of elasticity (ME) were relatively low in the thermoplastic resins, they demonstrated great toughness and strong resistance to fracture. Their flexibility can be enhanced by adding elastomeric resins. They can be also reinforced by adding glass filler or fibers.

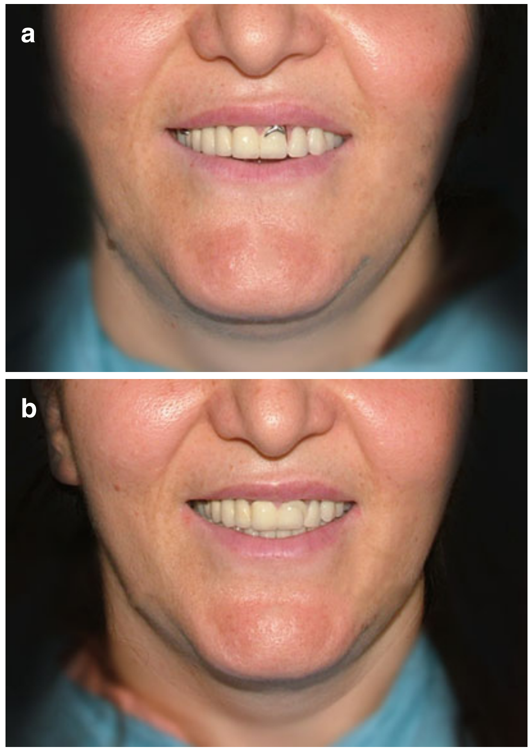

Fig. 12.1 (**a**, **b**) An acetal resin clasp in the anterior zone can be more satisfactory aesthetically than a metal clasp

General disadvantages of nonmetal clasp dentures

1. Thermoplastic materials need special attention because they are affected by heat generation during polishing. If the glass transition temperature is exceeded, the structure may become rubbery.

   It was shown that a polyamide denture base becomes more than 7 times smoother and a processed polymethylmethacrylate becomes more than 20 times smoother when they are polished with the same conventional polishing technique.
2. The polished surface of the thermoplastic resins may lose their brightness over time because they are softer than acrylic resin and more easily damaged by the scratch test. Therefore, NMCDs should be brushed with soft materials and checked at short-term intervals. Discoloration and degradation of thermoplastic resin may also be observed. Although thermoplastic resins need more care

in terms of oral hygiene, in patients with good oral hygiene, candida growth will not be a problem.
3. It is difficult to adjust and repair NMCDs because generally they do not adhere to the self-cure acrylic resin. It should be remembered that distal extension NMCDs should have maximum tissue support. An altered cast impression technique (see Chap. 8) can improve support in distal extension NMCDs and delay relining requirement.
4. If the resin clasp is in the form of extending a part of the thermoplastic denture base resin, it covers the cervical area of the abutment teeth. This design may lead to periodontal problems. Additionally, the thickness of the preformed clasps may cause the same problems. Therefore, careful cleaning is very important.

It can be easily understood from the abovementioned disadvantages that thermoplastic resin materials have different limitations and their properties need to be modified. More clinical studies are needed for their improved usage.

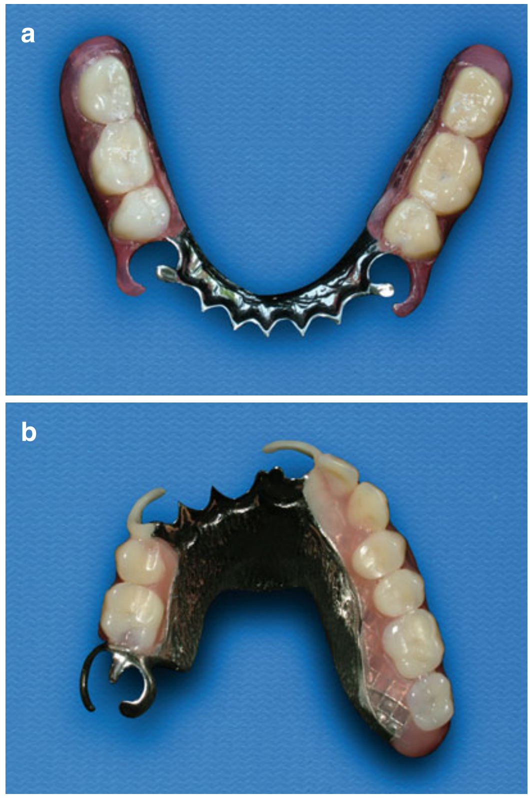

Fig. 12.2 (**a**, **b**) Nonmetal clasp dentures should be fabricated with metal framework and its design should be the same as conventional removable partial denture except the clasps

12.2.1 The Basic Principles for Clinical Use of Nonmetal Clasp Dentures with Different Thermoplastic Materials

The basic requirement of a major connector is rigidity. NMCDs which do not include a metal structure lead to traumatic damage to the periodontal tissue of the abutment teeth and impingement of the underlying tissue due to their flexibility. NMCDs with a metal framework are rigid. Therefore, NMCDs including a metal structure with metal rest are recommended to avoid sinking and flexion of the denture base, and they can be used for all patients whose priority is aesthetics. It is very important to remember that the NMCDs should follow the same design principles as conventional RPDs with metal clasps (Fig. 12.2a, b).

However, nonmetal clasp dentures that do not include a metal structure can be a treatment option in patients with metal allergy and in patients with few missing anterior teeth or few missing teeth with occlusal support. Additionally, they can be used as epithesis for patients for whom the dentures carry no functional burden and for patients who do not consent to the preparation of their abutment teeth even for rest seats and, for implant patients, as an interim denture.

As mentioned above, thermoplastic resin clasps can be fabricated in two ways. The design criteria of thermoplastic resin retainers depend on the ME of the resin. As the ME of the material increases, rigidity also increases. Hence, the material with the lower modulus of elasticity will be more flexible and can be used in the deeper undercut (e.g., polyamides have lower ME than polyoxymethylenes).

In the first design, the resin clasp is in the form of extending a part of the thermoplastic denture base resin, and in the second design, a preformed resin clasp is used with a polymethylmethacrylate denture base material.

Polyoxymethylene (acetal resin) is the most commonly used preformed clasp material in dentistry. It is also used as a base material for patients with an allergic reaction to chrome-cobalt framework because it is monomer free. Although manufacturers suggest the use of this material without a metal framework, a metal framework offers better rigidity as can be seen with other thermoplastic materials.

This material is very strong and resists wear and fracture. It also exhibits high creep resistance and high fatigue endurance. It has clinically acceptable discoloration values. It is also reported that the water sorption and the solubility of acetal resins were within ISO specification limits, and an acetal resin showed clinically acceptable color changes for peroxide cleanser but unacceptable for hypochlorite cleanser.

It is more flexible but has a lower retentive force when compared to the chrome-cobalt clasp. Thus, it should be placed in deeper undercuts (approximately 0.5 mm) on abutments rather than chrome-cobalt. It has been recommended that an acetal resin clasp should be fabricated shorter with a larger cross-sectional diameter in order to have a stiffness similar to a cast chrome-cobalt clasp (if all other variables are equal, an acetal resin clasp should be 5 mm long and 1.4 mm in diameter, instead of 15 mm long and 1 mm in diameter chrome-cobalt clasp – Dental D). A study result showed that a 1 kg force was required to dislodge Dental D clasp's tips by 0.5 mm, using its dimensions according to the manufacturer recommendation (length 12 mm, thickness 1.9 mm tapering to 1.25 mm at the tip, width 2.8 mm tapering to 2.2 mm at the tip).

If plaque control is established, a thicker clasp will not be harmful to oral health. It is also recommended to benefit from guiding planes in order to provide more retention. Retention will also be affected by the number of clasps, the fit of the framework, and the depth of undercut (Fig. 12.3).

Acetal resin does not have natural translucency but is available in various color shades. It can be fabricated in the same shape as a metal clasp without covering the gingiva. A metal framework

Fig. 12.3 The retention of an acetal resin clasp is less than a metal clasp. Therefore benefiting from the guiding planes and using sufficient undercut are necessary to obtain adequate retention

Fig. 12.4 Acetal resin clasps are fabricated before acrylic polymerization. Thus it is possible to check the retention and color harmony during the esthetic try-in

is fabricated in a conventional manner. After intraoral try-in of the framework, the jaw relations are recorded. In laboratory procedures, a wax pattern of an acetal resin clasp is manufactured and an injection carried out and shaped in the metal framework's mesh. Thus, it is possible to check the retention and color harmony of acetal resin clasps during the aesthetic try-in (Fig. 12.4).

Polyetheretherketon and polyetherketonketon have also been used as a material for clasp fabrication in the same manner as polyoxymethylene. It was found that all three thermoplastic resin clasps (Bio XS, PEEKtone A, Acetal Dental) showed their greatest retentive force at 1.5 mm thickness with a 0.50 mm undercut and provided adequate retention for RPDs even after 10 years

Fig. 12.5 (**a**–**c**) Polyamide base removable partial denture's color harmonizes well with the color of the gums

of simulated use. It was concluded that the retention of adequately designed resin clasps might be sufficient for clinical use.

Although a clinical study showed that the acetal resin clasps were superior to chrome-cobalt clasps as they produced fewer reductions in bone height and in bone density around the abutment teeth, it should be noted that more randomized clinical studies are needed.

Thermoplastic polyamides, commonly known as nylon/flexible dentures, have also become widely used in dentistry. Although there are not enough studies of all brands, it is shown that the characteristics of polyamides differ from brand to brand. The most noteworthy and clinically important additional differences from the abovementioned advantages and disadvantages based on some studies are as follows for commonly used materials: Valplast's and Deflex's colors harmonize well with the color shades of the gums (Fig. 12.5a–c). Valplast can be disinfected with glutaraldehyde or sodium hypochlorite without changing its surface roughness. But a study showed that all three sodium perborate-containing denture cleansers (Corega, Protefix, Valclean) increased surface roughness of the polyamide materials (Valplast, Deflex). Color changes (Valplast) can occur with some foods and beverages such as curry, coffee, and wine. A study result showed that Deflex also has displayed more color changes when compared to polymethylmethacrylate and tea was the most effective beverage on color changes for all base materials. As Valplast does not bond to acrylic resins, treating the surface with 4-META/MMA-TBB resin after sandblasting has been recommended.

Polishing and grinding are easier for Lucitone FRS because it is harder than Valplast and highly resistant to abrasion. But the risk of fracture, color instability, and the difficulty of relining and repairing are considered disadvantages. It should be noted that the preparation of appropriate retention holes for artificial teeth is very important for the two of them. Ultimate is a new material about which there is little information. Relining and repairing can be fabricated by reinjection of the material, and it can also be used for the relining and repairing of the Lucitone FRS.

Polyesters (EstheShot, EstheShot Bright) are thermoplastic base materials which are relatively new. They have lower resilience and better fitting than polyamides and polycarbonates. Unlike polyamides, repairing is possible with self-curing resin. Alkaline denture cleaners may lead to degradation on the surface of the polyesters.

Reigning which is *polycarbonate* has similar physical properties to polyesters but lower water absorbency. Denture cleaners do not affect the material. Relining with self-curing resins may result in peeling. It can be reinjected to repair the broken clasp, and also repairs can be done with special repair materials. Another polycarbonate material Reigning N's surface is harder than polyamides and polyesters. Discoloration is less than other resins. It bonds to self-cure resin. There are artificial teeth made of the same material which therefore do not need special retention for both materials.

The retentive forces of all thermoplastic resin clasps depended on the different factors such as ME, thickness, and the width of the resin and the amount of the undercut. If a thermoplastic clasp is fabricated as an extending part of the denture base, the recommended width of the retentive arm is approximately 5.0–6.0 mm and the thickness of the clasp arm is 1.0 mm (Fig. 12.6a, b). Thus, in clinically short crowns with inadequate sulcus depth and/or an excessive undercut in the tissue part, the width of the retentive arm may not be properly designed. In the case of missing molars, a study indicated that if there is presence of a 0.75 mm undercut on the second premolar, a polyamide resin clasp covering only the buccal surface is desirable, but in the presence of a 0.50 mm undercut, a resin clasp should also be extended to the buccal surface of the first premolar (Fig. 12.7). As a deeper undercut was found more effective than that of a design covering the anterior abutment tooth, it is also necessary to use lingual and proximal undercuts to increase retention. However, it should be kept in mind that further studies on the design of the resin clasps are still needed.

In clinical steps, the metal framework is fabricated. Jaw relations are recorded. Artificial teeth are arranged. After completing the aesthetic try-in, the denture is forwarded to the laboratory. The denture base, including the clasps, is manufactured with thermoplastic resin.

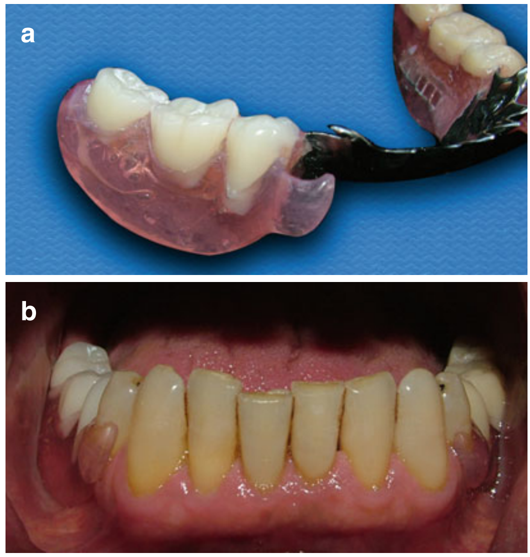

Fig. 12.6 (**a**, **b**) Recommended polyamide clasp width is approximately 5.0–6.0 mm and thickness of the clasp arm is 1.0 mm

Fig. 12.7 In cases having no molars, in the presence of 0.5 mm undercut on the second premolar, a thermoplastic resin clasp may be extended to the buccal surface of the first premolar to obtain adequate retention

In light of the above data, it is clear that the dentist should have detailed information about the material before its clinical application.

12.3 Rotational Path Removable Partial Dentures

It is possible to eliminate the clasps in the aesthetic zone by using the rotational path of placement (Fig. 12.8). Additionally, in the presence of severely tilted teeth, the placement of the RPD is possible by using the rotational path design. A straight path of placement is used in the conventional design. But in the rotational path design, one portion of the framework is seated first, and later the other portion of the framework is seated (Fig. 12.9). Retention is obtained from the proximal undercuts adjacent to the edentulous spaces. Rigid retentive units consist of a rest and a minor connector. The retentive minor connector is frequently formed with a gingival extension on the teeth.

The primary indication of the rotational path design is for tooth-bounded partially edentulous arches. Namely, applying this design is more suitable for Kennedy Class III and IV cases. Although one clinical study that evaluated Kennedy Class III and II (without anterior modification) case results revealed that the rigid retainers demonstrated support, stability, retention, adequate encirclement, and passivity at the end of 10 years or more follow-up, further clinical studies are still needed in order to expand the indications for this design.

Fig. 12.8 If appropriate cases are chosen, a correctly designed rotational path RPD will be a very satisfactory esthetic solution for patients

Advantages of the rotational path RPD design

1. The clasps can be eliminated in the aesthetic zone.
2. Plaque accumulation may be decreased by reducing tooth coverage.
3. Preparation on the abutment teeth is minimally invasive.
4. Facial or lingual undercuts are not necessary for retention.
5. Further tipping of the abutment tooth can be prevented by a rigid retainer.

Disadvantages of the rotational path RPD design

1. Fabrication and adjustment may be more difficult when compared to conventional design because technicians are less familiar with this design and processing errors are less tolerable.
2. The well-prepared rest seat preparation is vital.

There are two categories of rotational path designs. In *category I design*, the rotational centers of the framework are located at the ends of

Fig. 12.9 Placement of a rotational path RPD is different from a conventional RPD. While straight path of placement is used in conventional RPDs, rotational path RPD’s one portion is placed first, and later the other portion is placed. Path of placement shows differences according to the rotational centers (Video 12.1)

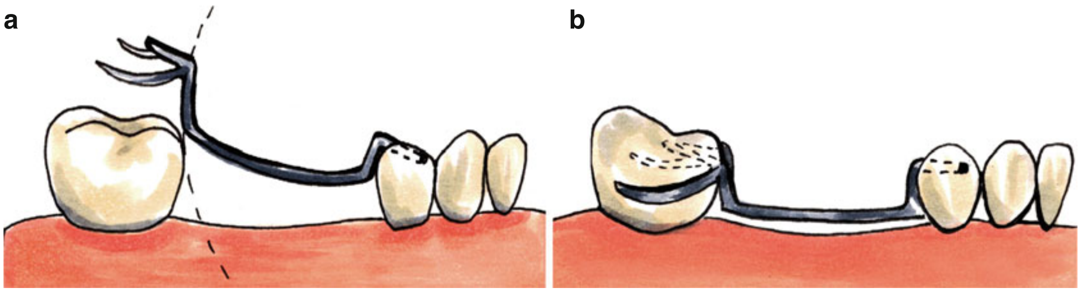

Fig. 12.10 (**a**, **b**) Anteroposterior category I rotational path design

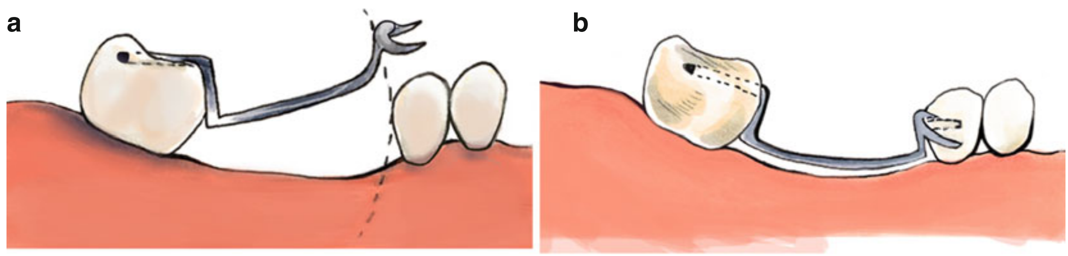

Fig. 12.11 (**a**, **b**) Posteroanterior category I rotational path design

the rests of the rigid retainers. The rotational centers are seated first, and then the entire prosthesis is placed to its final position. Depending on aesthetic and periodontal considerations, the anterior or posterior portion of the RPD is placed first. Elimination of either anterior or posterior clasps with this design is possible. If the anterior portion of the prosthesis is placed first, the path of placement is termed *anteroposterior*, and generally it is used to eliminate the anterior clasp (Fig. 12.10a, b). If the posterior portion is placed first, the path is termed *posteroanterior*, and generally it is used to eliminate the posterior clasp (Fig. 12.11a, b). When molar abutments are tipped mesially, this design offers a great advantage (Fig. 12.12).

Fig. 12.12 In cases having mesially tilted molars, the posteroanterior category I rotational path design can be used, and the minor connector on the mesial guiding plane of the molar abutment serves as the retentive unit

In *category II designs*, rotational centers are placed gingivally as rigid extensions of the minor connectors and are primarily used to replace the anterior teeth with the elimination of anterior clasps (Fig. 12.13). This category includes all lateral paths.

Rests in the rotational path design show small differences from conventional design. In molars, rest seats should be prepared 1.5–2 mm deep occlusogingivally with nearly parallel buccal and lingual walls on the molar abutments. Rest seat preparation should be extended to more than half the mesiodistal width of the occlusal surface to provide bracing and vertical distribution of the forces to the abutment teeth and to prevent tooth migration. Preparation of the irregular outline form also prevents migration (Fig. 12.14). If molars are also tipped lingually, their rest seat walls should be prepared parallel to each other.

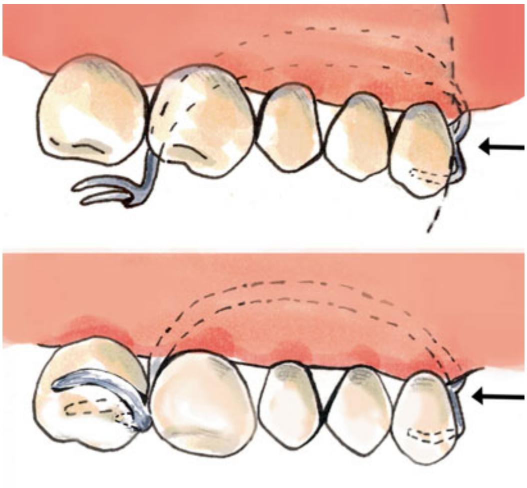

Fig. 12.13 Category II rotational path design

Fig. 12.14 On the molars that the clasps are eliminated, rest seat preparations are extended to more than half the mesiodistal width with an irregular outline form

A cingulum rest seat on the anterior teeth should be prepared. When suitable cingulum does not exist, it can be provided by acid-etched composite resin or fabricating a crown restoration. The outline form of the preparation should be an inverted "U" or "V" and extended to more than one half the mesiodistal width of the anterior tooth.

Conventional clasping and rest can be used wherever necessary in all designs.

Regardless of the design category, rigid retainers should be passive during and after seating of the framework, and therefore they do not require reciprocation.

It is important to remember that the lingual bar design causes fewer problems when establishing a rotational path of insertion in the mandible. The lingual plate is more likely to cause interferences as the surface covered is much greater. So if possible a lingual bar should be preferred over a lingual plate.

Steps of clinical and surveying procedures

1. The patient's acceptance and coordination are assessed. Intraoral evaluation is performed to determine whether a rotational path design is possible or the presence of proximal undercuts, the location and number of edentulous areas, and the arch form. Occlusal relationships are evaluated both clinically and on the mounted casts. Then the study casts are investigated in terms of adequate undercuts when the cast is surveyed with a zero-degree tilt. Rest and retentive areas are also investigated. The amount of undercut should be approximately 0.5 mm in the retentive area. Although guiding plates are not usually recommended for this design, recontouring in the required areas is performed to minimize the amount of relief.
2. Rest seat preparation is performed. If there is no proper cingulum to prepare the rest seat and/or adequate undercut, crown or bonded composite resin restorations can be provided. Composite restorations are generally recommended in completing rest seats to improve contours and to alleviate the patient's financial constraints.

   After the final impression, the cast is surveyed again. The heights of the contours are drawn at two different positions (at the zero-degree and tilted positions) (Fig. 12.15a–c). Retentive areas and undercuts are indicated on the cast. The analyzing rod is utilized to assess whether access exists for the rests to be seated. If not, extra preparation is required which eventually needs a new impression.
3. An acrylic prototype resembling the metal framework may be helpful to check the rotational path of insertion. Thus, any obstacles detected during try-in can be handled before casting.

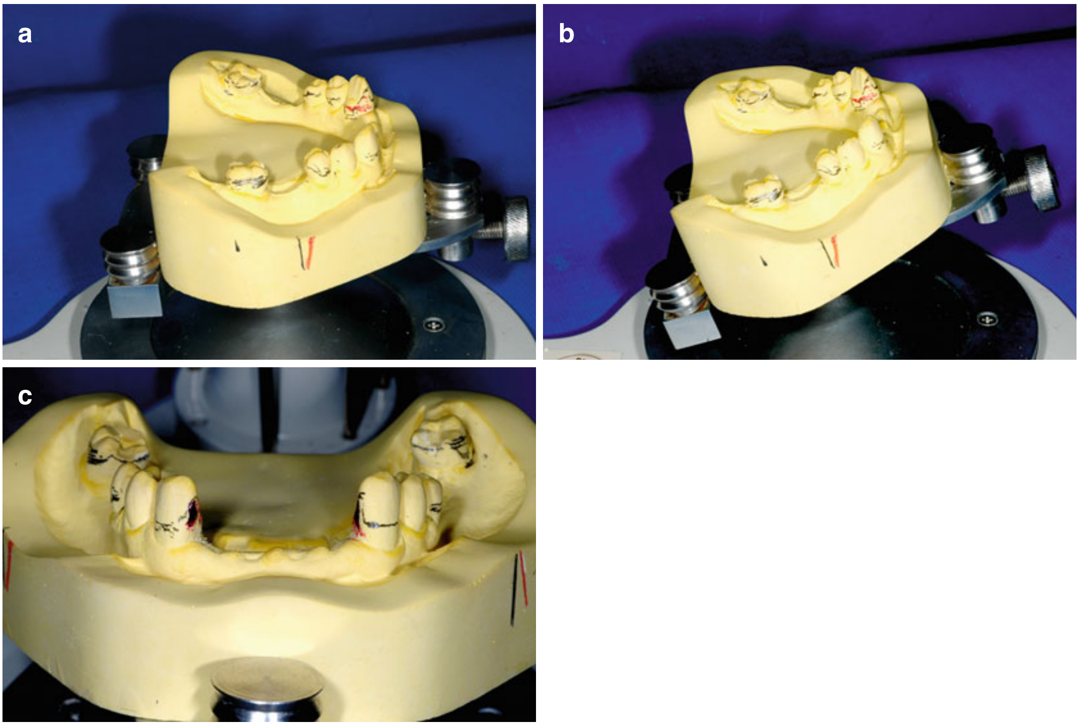

Fig. 12.15 (**a**–**c**) Rotational path RPD's retentive areas are determined on the surveyor. The heights of the contours are drawn first at zero-degree (**a**) and later at tilted positions (**b**). Retentive minor connector will be placed between the two lines (**c**)

Fig. 12.16 (**a**, **b**) Retentive minor connector should be adjusted chairside by the dentist and the technician should be warned not to grind these areas (**a**, **b**)

4. During the adjustment of the metal framework, care should be given to preserve the surface of minor connectors that are facing the abutment teeth and act as rigid retainers. If necessary, these surfaces should be adjusted chairside by the dentist (Fig. 12.16a, b). However, any interference with the framework regarding the rotational path of insertion has to be eliminated during laboratory finishing.
5. In order to determine the shape and amount of blockout under the minor connector and whether there is adequate undercut for the rigid retentive component, a pair of compasses can be used (Fig. 12.17).The free arm tip of

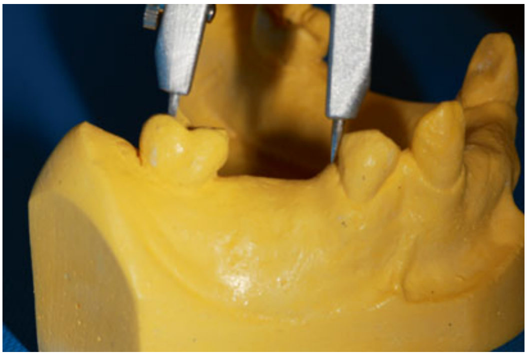

Fig. 12.17 A pair of compasses can be used to assess undercut areas in terms of both amount of adequate undercut and blockout on abutment teeth

the compass is used to evaluate the undercut area during motion around the other arm tip which is fixed at the rotation axis. If multiple edentulous areas exist, a sufficient blockout of undesirable undercuts should be planned for all minor connectors.

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Establishing Occlusal Relationships

13

Tonguç Sülün

13.1 Definitions

Arcon A contraction of the words "articulator" and "condyle," used to describe an articulator containing the condylar path elements within its upper member and the condylar elements within the lower member.

Arcon articulator An articulator that applies the arcon design; this instrument maintains anatomic guidelines by the use of condylar analogs in the mandibular element and fossa assemblies within the maxillary element.

Bennett angle The angle formed between the sagittal plane and the average path of the advancing condyle as viewed in the horizontal plane during lateral mandibular movements.

Check-bite A registration of the positional relationship of the opposing teeth or arches; a record of the positional relationship of the teeth or jaws to each other.

Curvilinear Consisting of or bounded by curved lines; represented by a curved line.

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Deprogrammer Various types of devices or materials used to alter the proprioceptive mechanism during mandibular closure.

Dual bite The anteroposterior difference between the RCP and ICP exceeds 2 mm and if two occlusal positions can easily be taken up.

Freedom in centric The range of tooth contacts in maximum intercuspation.

Gothic arch tracer The device that produces a tracing that resembles an arrowhead or a gothic arch. The device is attached to the opposing arches. The shape of the tracing depends on the relative location of the marking point and the tracing table. The apex of a properly made tracing is considered to indicate the most retruded, unstrained relation of the mandible to the maxillae, i.e., centric relation.

Maximal intercuspal position (MIP) The complete intercuspation of the opposing teeth independent of condylar position, sometimes referred to as the best fit of the teeth regardless of the condylar position—called also maximal intercuspation.

Split-cast method 1: A procedure for placing indexed casts on an articulator to facilitate their removal and replacement on instrument 2: the procedure of checking the ability of an articulator to receive or be adjusted to a maxillomandibular relation record.

Vertical pin That component of an articulator, generally a rigid rod attached to one member,

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contacting the anterior guide table on the opposing member. It is used for the purpose of maintaining the established vertical separation. The (anterior guide) vertical pin and incisive table, together with the condylar elements, direct the movements of the articulators' separate members.

There are multiple ways to achieve a proper occlusion in a partially edentulous patient. It is important to know that every patient has individual functional and aesthetic needs and expectations. The clinician has to decide first if the existing natural or artificial occlusion of the patient is acceptable or if there is anything to change in intercuspal position and/or occlusal vertical dimension. In cases that require a reestablishment of the existing occlusion, a functional pretreatment is generally necessary.

When there is an extremely worn dentition, it may cause a decrease in the occlusal vertical dimension of the patient (Fig. 13.1a, b). So we have to reestablish a new one. However, there are many cases with severely worn dentitions where occlusal vertical dimension is not decreased. Up to date, there is no explanation in the literature that explains why the occlusal vertical dimension is sometimes preserved by the remodeling process in the alveolar bone and sometimes not. Nevertheless, the rehabilitation of these cases is the most challenging part of the prosthetic dentistry. Reestablishing the occlusal vertical dimension of these patients to achieve a sufficient interocclusal space will be explained in Chap. 22. However, it is important to point out here that this process may take 4–10 weeks. Only after a sufficient pretreatment procedure the final denture should be prepared.

In cases with decreased occlusal vertical dimension due to worn dentition or where the residual dentition has no occluding contacts, the recording of vertical jaw relations is nearly the same as in complete denture patients. This procedure will also be explained in Chap. 22.

First of all, it is important to decide whether there is an acceptable intercuspal position; if not, the retruded contact position (RCP) of the patient should be recorded.

Fig. 13.1 (**a**) A patient with severely worn dentition with the removable partial denture (RPD) in maximal intercuspal position (MIP). (**b**) Intraoral view of the existing removable partial dentures (RPD)

13.2 Deciding the Type of Horizontal Relation

13.2.1 Using the MIP as a Reference

- Where the patient has no TMD or functional problems in the stomatognathic system
- Where there is no need to change the occlusal vertical dimension
- Where there are sufficient occluding posterior teeth
- In patients with small gaps in dentition

13.2.2 Using the RCP as a Reference

- Where the patient has TMD or functional problems in the stomatognathic system
- Where the occlusal vertical dimension needs to be increased
- Where there are no occluding teeth or only the anteriors are in contact
- Where complex treatment modalities, full mouth rehabilitation, etc., are needed

13.2.3 Exceptional Cases in Using MIP/RCP as a Reference

- Geriatric patients with pseudoprognathism

Because of the lack of the neuromuscular adaptation of these patients, it is logical to prefer the habitual intercuspal position as a reference.

- Patients with extreme Angle Class II Div 1 jaw relations (Fig. 13.2a, b)

These patients have an extreme dual bite which is present when the anteroposterior difference between the RCP and MIP exceeds 2 mm and if both occlusal positions can easily be repeated. If the RCP is recorded as a reference in these patients, a considerable overjet occurs in between the anterior teeth (Fig. 13.3). So the patient will never be able to close her/his jaw in a more anterior position. And if the maximum intercuspation is created in RCP, a freedom-in-centric concept will not help. Obviously, because of the proprioceptive receptors in the periodontium, patients tend to close their mandible in a position with maximum tooth contact. Thus, the restorative occlusion and maximum intercuspation should be created in maximum intercuspal position (MIP), and only then the occlusal equilibration should be prepared from MIP to RCP, for both groups of patients. Finding and recording the MIP when there are no occluding teeth anymore is a challenging procedure. Owing to this difficulty, the best way is using an intraoral gothic arch tracing device. After the patient traces the gothic arch, the tip of the arrow will mark the surrounding counters of the metal plate. Then the surface is repainted, and the patient is asked to tap her/his mandible several times. After a while, there is a gathering of points in the painted surface which is called the "adduction point." This point or area can now be used for recording the MIP (Figs. 13.4a, b and 13.5a–e).

After deciding between MIP or RCP as a reference, the next logical step is to choose the method for recording the horizontal jaw relations. According to the type of partial edentulism, we can use a base plate and occlusion rims or opt for the check-bite method.

Fig. 13.2 (**a**) Intraoral view of the wax try-in of a removable partial denture (RPD) in maximum intercuspal position (MIP). (**b**) Intraoral view of the wax try-in of a removable partial denture (RPD) in retruded contact position (RCP)

Fig. 13.3 A case with maxillary complete and mandibular Kennedy Class I edentulism. The occlusion in retruded contact position. Please notice the extreme overjet

13.3 Deciding the Method of Recording Horizontal Relations

13.3.1 Using a Base Plate (or Metal Framework) and Occlusion Rims to Record Horizontal Jaw Relations

- Where no teeth are in contact with the antagonist
- Where the teeth are severely worn and the occlusal vertical dimension is decreased
- Where just the anterior teeth are in contact

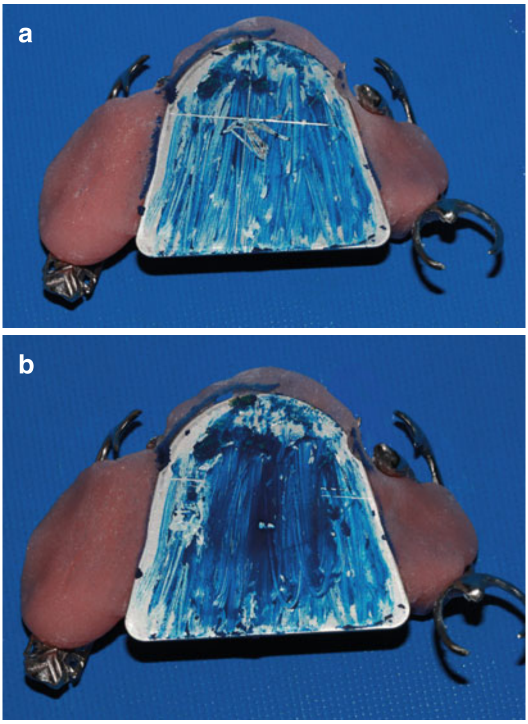

Fig. 13.4 (**a**) The Gothic arch tracing of the case in Fig. 13.3. (**b**) The tapping point. Notice the difference between the tapping point and the apex of the Gothic arch

13.3.2 Using Check-bite Method to Record Horizontal Jaw Relations

- Where sufficient teeth are in contact with an acceptable occlusal relationship
- Where sufficient teeth are in contact and there are some premature occlusal contacts with or without a major discrepancy between MIP and RCP

Using the check-bite method for recording the horizontal relationship is only preferred when mounting the study models to the articulator. If the patient has an acceptable occlusion and no TMD or functional disorders of the masticatory system, the softened wax blocks or other materials like bite registration silicones can be used directly as recording materials. However, in cases with occlusal discrepancies or disharmonies, we should use an anterior bite plane (so-called deprogrammer): In some cases, a premature occlusal contact can be the reason of the destruction of the periodontal ligaments along with bacterial insertion and that may cause the mobility of the tooth. If the clinician does not use a deprogrammer between the anterior teeth, the patient will bite on the mobile tooth, and it will move to a wrong position, resulting in failure of transferring the mandibular position with premature occlusal contact to the articulator.

In cases with discrepancies between MIP and RCP and/or functional disorders of masticatory system, it is a challenging act to bring the mandible to the desired position. The deprogrammer behaves like a short-term occlusal splint to stabilize the muscles and temporomandibular joints (TMJ) of the patients.

An anterior bite plane which produces a gap of 1.5–2 mm between premolar teeth is an ideal construction. It is important to know that in patients with an uncontrolled and extreme bite force, it is preferable to use a deprogrammer made of a compound (Kerr compound red) instead of acrylic, because excessive biting on the anterior bite plane may cause a retrusive movement of the mandible, especially if the surface inclination of the deprogrammer is not correctly perpendicular against the axis of mandibular anterior teeth. The anterior bite plane made of a compound will immediately crack if the patient bites intensely. Thus, the compound material plays a safety mechanism role for the gentle bite of the patient.

13.4 Articulators

First of all, to analyze the occlusion and to fabricate a potential interim prosthesis or an occlusal device, the abovementioned records should be transferred to the articulator. There are basically two ways for this procedure:

- Positioning both maxillary and mandibular study models with the bite registration according to the instructions of the articulator company. As landmarks, the incisal pin and the two notches beside the articulator's frames are used. If these landmarks are used to correct the occlusion plane of the study models, the positions will be usually in the center of the articulator and parallel to the floor.

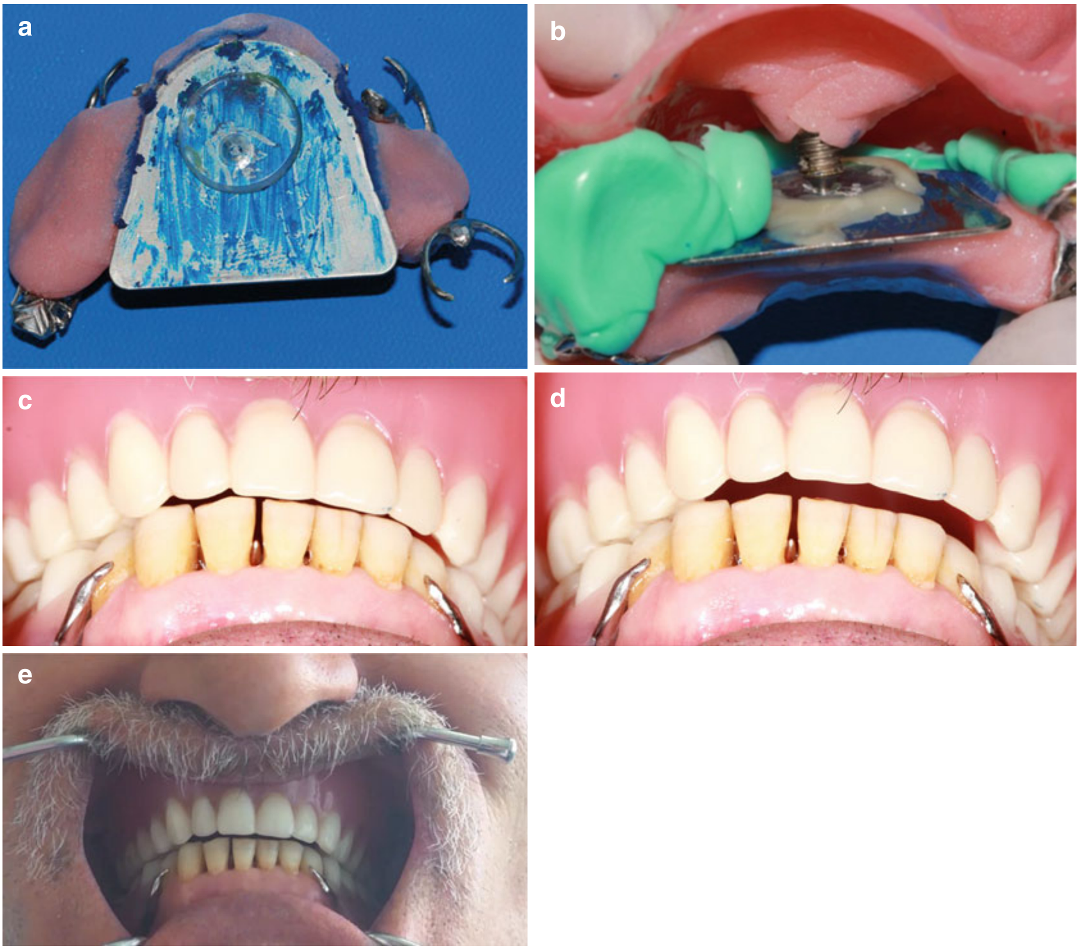

Fig. 13.5 (**a**) In this case, the tapping point is chosen as a reference for centric record instead of the apex of the Gothic arch. (**b**) The centric record. Lingual view. (**c**) The intraoral view of the prosthesis in maximum intercuspal position (MIP). (**d**) The intraoral view of the prosthesis in retruded contact position (RCP) (**e**) The slide between MIP and RCP (Video 13.1)

- Using a face-bow to transfer the maxillary (usually) model to the articulator. In current dental literature, there is a discussion about the necessity of face-bow usage.

13.4.1 Using Face-bow

According to the *Glossary of Prosthetic Terms*, face-bow is a compass-like instrument, which records the spatial position of the maxilla and transfers this relation to an articulator. So, by using a face-bow, the distance between each tooth and center of condyles will be transferred just as it is in the skull. For a compass, if the distance between the needle and printer differs, the printer draws circles with a different radius. Just as here, teeth which have different distances from the center of rotation (condyles or rather centers of articulators' condylar spheres) draw different circles during the opening and closing movement of the mandible. This means, when changes are made in the occlusal vertical dimension or during adapting the models with a recorded check-bite (without a contact of opposite dentitions), different ways of opening and closing occur. If a face-bow is used in the transfer, the opening and closing ways will be the same as it is in the patient's mouth. Therefore, changes that are made with the articulator will also be the same as in the mouth.

The theoretical situation described above is well known since the first face-bow was introduced by Snow in 1907. However, in recent years, prosthetic literature shows that benefits of face-bows do not affect the clinical success as previously expected. Scientific studies claim that the clinical success of the prosthesis tends not to change with or without using the face-bow. However, little information has been given about the types of occlusion or morphological characteristics of patients included in these scientific studies. For an individual who has a normal-sized cranium and Angle Class I occlusal relation, the location of the models which are transferred using a face-bow to the articulator is nearly the same as the location of the models which are transferred arbitrarily (without using a face-bow). This occurs because articulators are fabricated in compliance with average characteristics of morphometric cranial properties and Class I occlusal relations. Thus, using a face-bow on normal individuals does not have a significant impact on the direction of opening and closing or functional pathways occurring during eccentric movements. Once this is acknowledged, the absence of a significant difference between treatment success and patient satisfaction should be regarded as normal.

Situations requiring face-bow usage can be outlined as the following:

In cases with prognathia inferior or retrognathia inferior, extremely small or gigantic skeletal structure, and laterognathia.

In cases with normal occlusion and morphometric characteristics, a face-bow transfer should only be applied if a full-mouth fixed prosthetic rehabilitation especially with gnathological problems is indicated.

In all other cases like FPDs with a few units and RPDs, the use of a face-bow is up to the practitioner's preference.

13.4.2 Important Aspects of Articulator Selection

Articulators are devices used by dentists and dental technicians. But prosthetic procedures can be easier and faster only if these two professions work harmoniously together. During intensive clinical work, it is difficult for a dentist to spare time for laboratory procedures such as mounting casts and adjusting articulators. These procedures are mainly applied by the dental technician alone. However, in order to provide the necessary guidance, the dentist should know about articulators as much as the dental technician. By the same token, although face-bow applications are only performed by a dentist, a technician should have the practical and theoretical knowledge about face-bow as he/she is the one transferring face-bow records to the articulator. Therefore, the dentists and technicians should encourage each other to work with the same articulator system to eliminate any deficiency.

The following titles describe the properties of a suitable articulator. In the market, there is an abundance of articulators possessing these properties. Be it as it may, the dentist should go for the same articulator used by his technician. In such cases, the dentist no longer has to send the face-bow to the technician, but only the appropriate part; the biting fork with the wax record will prove sufficient. The technician can readily transfer the face-bow recording to an articulator produced by the same company. Needless to say, in order to perform all these procedures correctly, the articulators have to be calibrated by the company beforehand.

13.4.3 Properties of a Suitable Articulator

1. Has to be Rigid

It is an indispensable point for an articulator to be made of a rigid material. It is impossible to maintain centric relation correctly for an articulator which is made of a flexible and deformable material.

2. Should maintain the centric relation

The most important property of an articulator is maintaining the centric relation, so the articulator should be rigid and should have an efficient centric lock mechanism. This is especially crucial for arcon articulators. Nonarcon articulators, however, can maintain centric relation very easily due to their typical structure.

3. Should receive face bow recording

The classification of modern articulators was altered due to their ability of face-bow transfer. Face-bows are indispensable elements for an articulator to mimic real jaw movements. If casts are mounted without face-bow records, the articulator will not be able to imitate mandibular movements even if it has been adjusted precisely.

4. Should have a vertical pin and incisive table

Articulators should maintain intermaxillary relations accurately. Also occlusal vertical dimension should be determined carefully for the prosthetic procedures. This can be preserved only if the device has a vertical pin. Within the determined vertical relation, changes during the prosthesis construction can be monitored by the dental technician and clinician. In addition, the numerical values of occlusal vertical dimension changes can also be recorded.

Almost all of the articulators have an incisive table. Not only the condylar path inclination but also the incisive path inclination should be individually adjustable. Incisive table can be adjusted in three different ways:

- It can be adjusted in lateral and protrusive ways with the screws (e.g., Dentatus).
- It can be adjusted by choosing the appropriate angled table (e.g., Gerber Condylator).
- Cold-curing acrylic resin is put on the incisive table, and the incisive path inclination can be adjusted by moving the vertical pin with the guidance of casts (e.g., SAM). After polymerization of the resin, an individually adjusted incisive table is ready to use. This procedure is used especially in cases which have anterior fixed hybrid rehabilitation. Primary casts which are made from unprepared tooth impressions are mounted to the articulator. Then the acrylic table is formed by using the casts' incisive path inclination. After the preparation of the teeth, casts for the fixed restorations can be constructed by using this acrylic incisive table.

5. Protrusive condylar path should be adjustable and curvilinear

The condylar pathways of the average value articulators are not adjustable. There is no objection to use this articulator with simple restorations stated above. However, an articulator should lend itself for all kinds of prosthetic works. At the end of the day, the choice of utilizing various abilities should be left to the dentist's preference, depending on the type of the prosthetic procedure. One should also be reminded that the individually adjusted protrusive condylar path provides a customized occlusal morphology of the posterior teeth and a palatal concavity of the upper incisors as well.

Recording of the Condylar Path Inclination
In this method, protrusive records are completed, following the centric record at the same appointment. Later, upper and lower casts are mounted to the articulator using centric records. The centric locks are loosened in order to allow eccentric movements. Protrusive records are placed on the lower teeth, and the upper casts are seated on it, while the condylar path inclination of the device is fixed to 30°. If both of the patient's condyle protrusive condylar path inclinations are not 30°, the upper casts cannot match with the record. For both sides, the protrusive condylar path inclination is moved above and below 30°, until the upper casts are properly seated; thus, this will be the patient's individual protrusive condylar path inclination. Doing this method with an upper cast which is mounted with the split-cast method is a more reliable way of avoiding the deformation of the bite registration material.

An appropriate articulator should have not only an adjustable condylar mechanism, but also

Fig. 13.6 The articular mechanism of the Gerber Condylator. The latero-protrusive movement (Video 13.2)

Fig. 13.7 The articular mechanism of the Gerber Condylator. The pure lateral movement (Bennett movement). Upper view (Video 13.3)

Fig. 13.8 The articular mechanism of the Gerber Condylator. The pure lateral movement (Bennett movement). Back view (Video 13.4)

this mechanism should have a correct curvilinear design. For an articulator with a linear condylar path, it is simply impossible to mimic natural mandibular movements.

6. Should simulate the Bennett movement (Figs. 13.6, 13.7, 13.8, 13.9, 13.10 and 13.11)

Bennett movement is known as 1 mm entire shifting of the mandible during lateral movement. Timing of this lateral shifting can be different. Immediate side shift is defined as shifting of the mandible at the beginning of the mandibular movement followed by the rotation of the working side condyle and moving of the nonworking side condyle in an anterior, medial, and caudal direction. This movement is observed in 80 % of the population, yet it is hard to record. Because this movement occurs at the beginning of chewing hard food, as

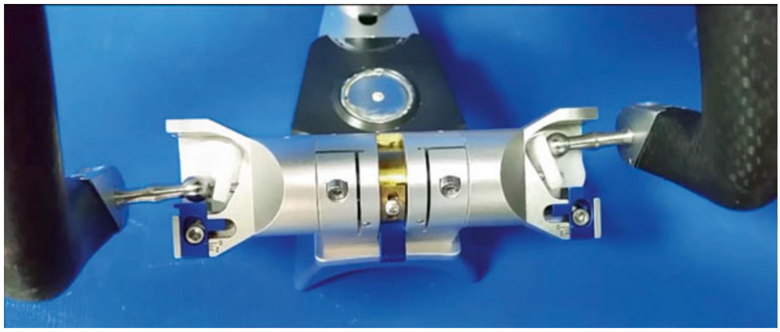

Fig. 13.9 The articular mechanism of the Girbach Artex articulator. The latero-protrusive movement (Video 13.5)

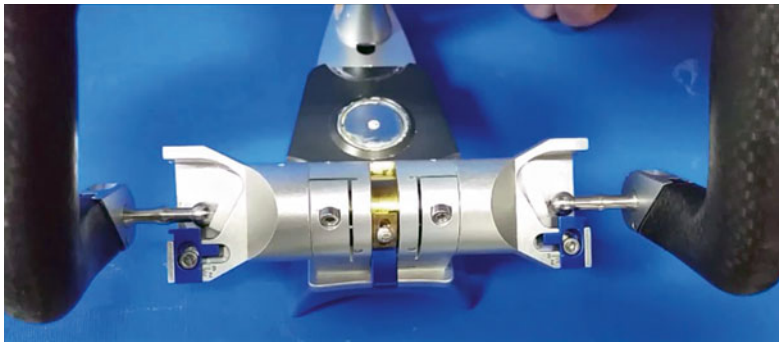

Fig. 13.10 The articular mechanism of the Girbach Artex articulator. The pure lateral movement (Bennett movement) (Video 13.6)

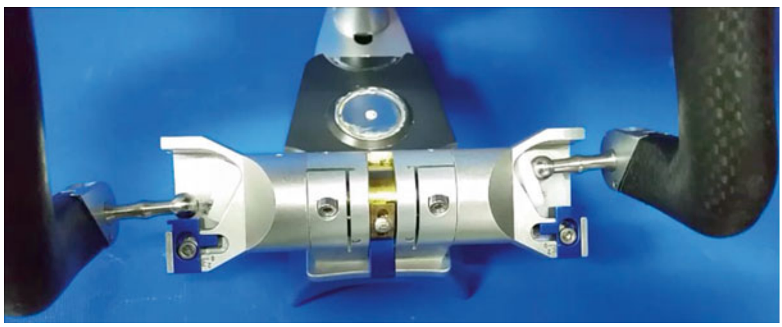

Fig. 13.11 The articular mechanism of the Girbach Artex articulator. The latero-protrusive movement with immediate side shift (Video 13.7)

the food softens, the range of the movement decreases. This motion has an impact on the occlusal morphology. In a person who has immediate side-shift movement, the angle between latero-mediotrusive functional ways is larger on the occlusal surfaces of the molars. If a person can do this movement where the articulator cannot, the functional ways of prosthesis are going to be formed with steeper angles. And when this prosthesis is used by the patient, there will certainly be occlusal interferences between cusps while chewing hard food. This happens especially on the nonworking side. It is nearly impossible to determine this interference in the mouth. In patients with complete dentures, these interferences cause destabilization of lower denture and sore points at the mandible. Also with fixed prosthesis, repeated fractures on occlusal surfaces of second molars, periodontal problems of the same tooth, and also myofascial pain at masseter muscle should be expected. Therefore, a patient will be more satisfied with his/her prosthesis that is produced using an articulator that contains an immediate-side-shift mechanism.

7. Should simulate the retrusive movement (Figs. 13.12 and 13.13)

Most of the articulators are capable of making lateral and protrusive movements, and

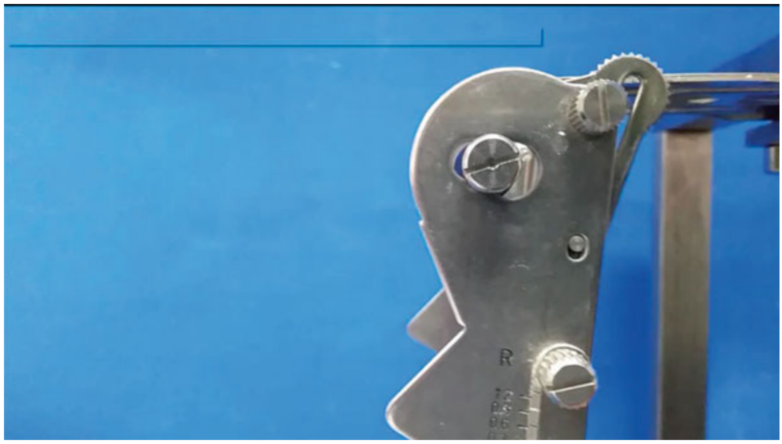

Fig. 13.12 The articular mechanism of the Gerber Condylator. The protrusive and retrusive movement (Video 13.8)

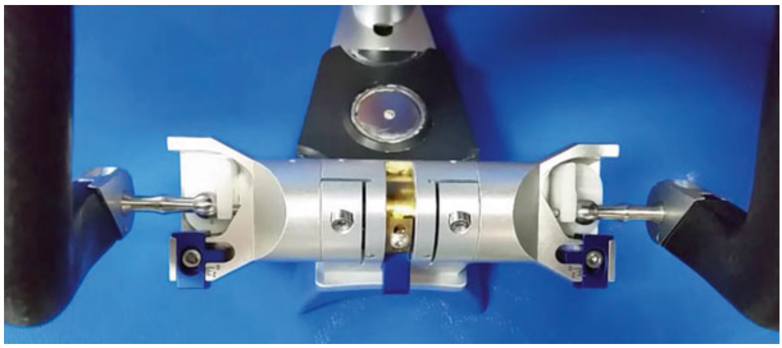

Fig. 13.13 The articular mechanism of the Girbach Artex articulator. The retrusive movement (Video 13.9)

some of them are even individually adjustable. Nevertheless, most of them cannot mimic the retrusive movement, which has an importance in chewing as shown by Gerber and Preti for many years. In some cases, horizontal jaw relations have to be recorded in MIP, and then the occlusion has to be adjusted in direction to RCP. Thus, an articulator with a retrusion mechanism is necessary. Otherwise, the clinician should adjust the occlusion by grinding the restoration to create the retrusive facets which will damage the occlusal morphology and cause waste of time at the chair site.

Commercially available articulators may differ from each other in retrusive mechanisms. For example, while the direction of the retral movement of Artex (Girbach) articulator is backward and upward, this direction in Gerber Condylator is backward and downward. A study in recent years encouraged that both movement patterns may occur in natural dentition.

13.5 Clinical Procedure

After checking the fit and occlusal relation to the antagonist teeth of the metal framework, it can be used as a base plate (Fig. 13.14). The denture base retentive mesh of the framework has a distal tissue stop in free-ending cases. However, this stop is mostly not sufficient because of the varied mucosa flexibility. Therefore, prior to the occlusion rims, the clinician should create a wax stop between the retentive mesh and the tissue surface of the cast. First, a softened wax is placed on the cast, and the heated metal framework is then placed on the model. It is dangerous to heat the metal casting on the flame because of the overheating risk. Therefore, heating the framework in boiled water is safer. The dentist should concentrate on visualizing the fit of all components of the framework on the cast. After placing the cast into cold water, the metal framework is removed from the model, and the excess wax under the major and minor connectors and guiding surfaces is scraped apart (Fig. 13.15). The framework is then rechecked for

Fig. 13.14 The metal frameworks that will be used as base plates

Fig. 13.15 The retentive mesh of the metal framework is supported with wax

Fig. 13.16 The occlusion rim is finished for the record of vertical and horizontal intermaxillary relations

the perfect fit in the mouth, and the occlusion rims are formed on the models (Fig. 13.16). First, the maxillary framework with occlusion rims is placed in the mouth, and the occlusal plane is adjusted parallel to the Camper plane and the straight line between the pupils (Fig. 13.17). In cases with infra- or supraerupted existing teeth or in cases where the occlusal plane is not parallel to these planes and the patient is reluctant to the preparation of the teeth, the occlusion rims are formed accordingly. After the occlusal plane is formed on the occlusion rims, the buccal contact of the occlusion rim is created. The occlusion rims should have a gentle contact with the buccal mucosa (Fig. 13.18). Only now, the mandibular metal framework with occlusion rims can be placed in the mouth to decide on the vertical and horizontal intermaxillary relationship (Fig. 13.19). If there is no antagonist of occluding teeth, the occlusal vertical dimension is determined same as in complete denture fabrication. If there are occluding teeth, the occlusal vertical dimension should mostly not be altered. However, in cases with decreased occlusal vertical dimension, the model analysis should be carried out before the metal frameworks are fabricated. As mentioned before, the centric relation is determined and

Fig. 13.17 The upper occlusion rim in the mouth of the patient. The occlusal plane is adjusted first

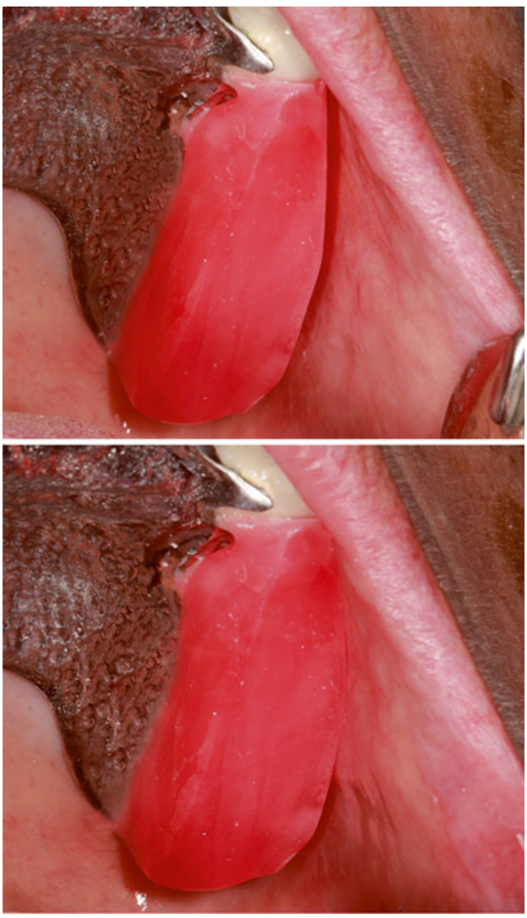

Fig. 13.18 The upper occlusion rim in the mouth of the patient. Please notice the contact between the buccal mucosa and occlusion rim

Fig. 13.19 The vertical and horizontal intermaxillary relations are adjusted

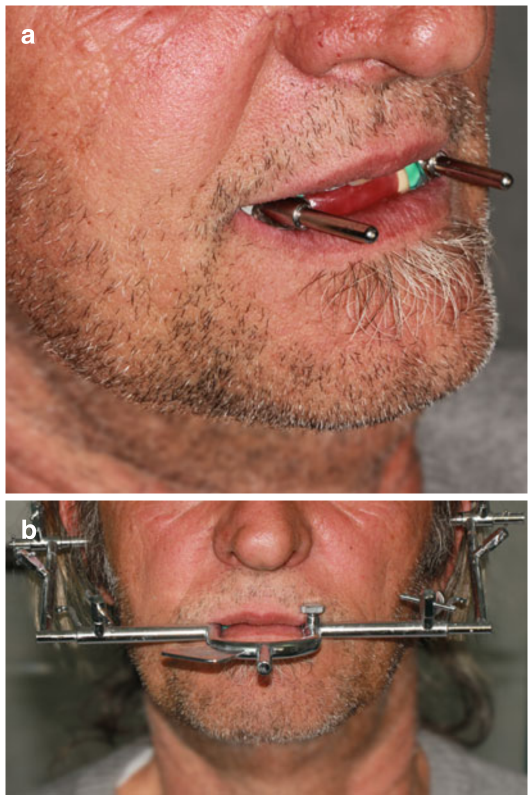

Fig. 13.20 (**a**) The intraoral metal frame of the face-bow is adapted on the mandibular arch. (**b**) The face-bow transfer

recorded in most of the cases in RCP. However, in Angle Class II Div 1 patients and pseudoprognathic cases, the MIP should be preferred. Prior to the fixation of the centric record, a face-bow record can be done if deemed necessary

Fig. 13.21 After the face-bow transfer, the centric record is made

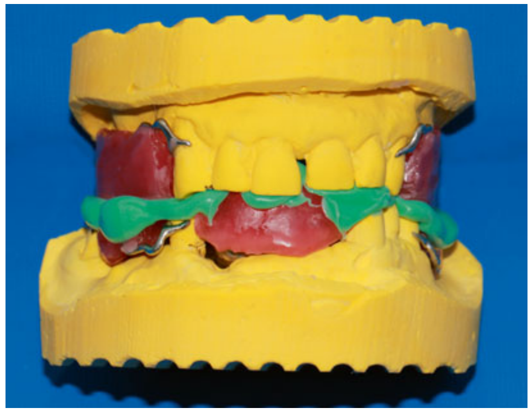

Fig. 13.22 The centric record is checked with the models

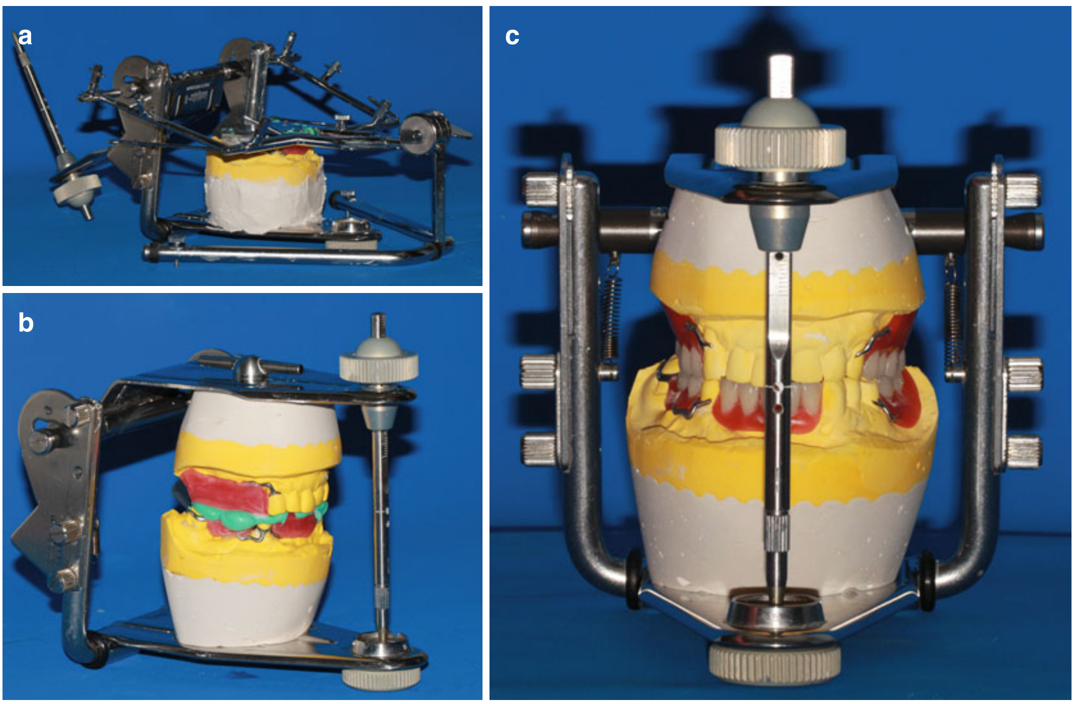

Fig. 13.23 (**a**) First the mandibular model is transferred to the articulator using face-bow record. (**b**) Afterward, the maxillary model is transferred to the articulator using centric record. (**c**) The teeth arrangement is finished

(Fig. 13.20a, b). After that, the centric record is made using a bite silicone material (Fig. 13.21). The frameworks are placed in the models, and the record is checked accordingly (Fig. 13.22). As a final step, models are transferred to the articulator, and the arrangement of the artificial teeth is now finished (Chap. 14) (Fig. 13.23a–c).

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14 Surveying and Laboratory Procedures

Max Bosshart and Burç Gençel

14.1 Definitions

Surveyor A paralleling instrument used in construction of a dental prosthesis to locate and delineate the contours and relative positions of abutment teeth and associated structures

Surveying The procedure of locating and delineating the contour and position of the abutment teeth and associated structures before designing a removable partial denture

Height of contour A line encircling a tooth and designating its greatest circumference at a selected axial position determined by a dental surveyor; a line encircling a body designating its greatest circumference in a specified plane

Survey line A line produced on a cast by a surveyor marking the greatest prominence of contour in relation to the planned path of placement of a restoration

Guiding planes Vertically parallel surfaces on abutment teeth and/or dental implant abutments oriented so as to contribute to the direction of the path of placement and removal of a removable dental prosthesis

Path of placement The specific direction in which a prosthesis is placed on the abutment teeth or dental implant(s)

Suprabulge That portion of a tooth or crown that converges toward the occlusal surface, i.e., above the height of contour

14.2 Surveying

14.2.1 Structural Units of a Surveyor

Basically a surveyor is used to analyze the axial surfaces of the teeth and other areas of a cast in relation to the vertical plane. There are almost a dozen different designs of surveyors; however, all of them function according to the simple principle of the first parallelometer that Fortunati used in 1918.

The main structural components of a surveyor are a horizontal bench with a cast holder which is capable of tilting and a vertical arm hanging at a right angle to the bench which can hold the surveying tools. The tilting table of the cast holder allows the individual horizontal plane for each cast to be adjusted so that the vertical arm functions perpendicularly to this acquired horizontal

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plane. The vertical arm can move up and down and its position can be fixed at any point. The functions of the surveying tools around the axial surfaces of the cast can be provided by the sliding ability of the cast holder over the benchtop or the roaming ability of the vertical arm over the horizontal plane, which depends on the design of the surveyor; however, most available models are decorated with both functions which provide easy and smooth operation. The main tools of surveying are the analyzing rod, carbon marker, and undercut gauges. The analyzing rod visualizes the surfaces in relation to the vertical plane, the carbon marker basically draws the survey line, and undercut gauges measure the depth of undercuts. Carving knife is also a useful tool especially during the evaluation of abutment teeth (Fig. 14.1).

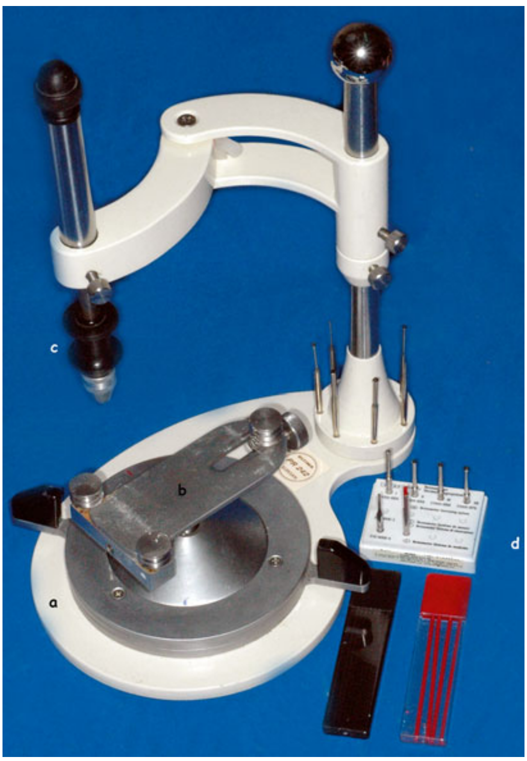


Fig. 14.1 Structural units and accessories of a surveyor. (*a*) Horizontal bench, (*b*) cast holder, (*c*) vertical arm, (*d*) analyzing tools (analyzing rod, carbon marker, undercut gauges, and spare marker tips)

14.2.2 Objective of Surveying

Partial edentulism is usually associated with edentulous areas of alveolar ridge accompanied by single or groups of teeth lacking relative parallelism and proper contours, which turn the design process into a biomechanical challenge. The biological and mechanical principles are integrated to planning, design, and construction phases by means of the surveyor.

The designer identifies the physical characteristics of oral tissues which may simplify or complicate the design of the denture by surveying. These are

- The amount and locations of retentive undercuts on abutment teeth
- Soft and hard tissue interferences
- Guiding plane surfaces

The acquired data, along with aesthetic considerations, will help to make the choice of a path of insertion and to establish the design of the prosthesis. With the benefits of surveying, an RPD with satisfactory aesthetics and calculated retention which allows easy insertion and removal by the patient can be constructed. Furthermore, the reduced gaps between the guiding surfaces not only improve aesthetics but also minimize food retention as well.

In case the surveyor is not used, the independently designed components of an RPD cannot be correlated; with each one bearing a different pathway, they cannot align to a single path of insertion, at least without exerting uncontrolled, probably harming, forces to the remaining structures or they cannot be inserted as a single unit at all.

14.2.3 Surveying: The Procedure

There are two stages of surveying. A preparatory analysis of the diagnostic cast is made to determine the favorable path of insertion and related necessary preparations before the final impression is made. Once the mouth preparation is complete, the definitive surveying is made on the master cast.

14.2.3.1 Systematic Steps of Surveying

1. Mount the cast on the surveyor, adjust the plane of occlusion as parallel as possible to the horizontal plane, and lock the tilting mechanism.

- It is very important to safely fix the cast on the cast holder. During surveying a number of precise measurements will be marked on the plaster surface. If the position of the cast is somewhat lost on the holder before tripoding, repositioning the cast is a complicated task which may result in confusing marks on measured surfaces.
- Fixing the vertical arm close to the occlusal plane and checking the distance to each tooth while roaming may help to adjust the plane of occlusion (Fig. 14.2).

2. The analyzing rod basically is the tool for determining the path of insertion. Attach the analyzing rod and make sure it works between the average occlusal plane and the bottom of the vestibular pouch vertically. The rod basically provides visual help to allocate undercut areas. Roaming in contact with the abutment teeth, it reveals the location and relative amounts of undercuts. After initial observation, tilting mechanism of the cast holder is released to distribute the undercut areas both for adjustment of retention, minimizing food traps, and to determine the path of insertion.

Regarding the path of insertion, it is primarily dependent on the nonretentive undercut areas on the lateral surfaces of abutment teeth facing edentulous spaces.

In most cases, dead zones, dark triangles between the analyzing rod and the gingival border, are present. To avoid large food traps and improper guiding surfaces, tilt the cast to set the vertical rod as the angle bisector between the long axes of relevant teeth. Practically, the dark zones are evenly shared between the abutment teeth (Fig. 14.3).

Some cases require aesthetic priorities due to missing anterior teeth. To eliminate the dark spots on axial undercuts and avoid visible clasp arms, these undercuts must be engaged to provide retention to the RPD. This is possible by employing a rotational path of insertion. Establishment of the rotational path provides retention from the anterior teeth with the retentive function of guiding plates (see Chap. 12).

The retentive undercuts of possible abutment teeth should also be evaluated in this step. Inspect the buccal surfaces of the teeth to determine the locations of retentive clasp arms. The cast may have to be tilted, usually slightly, to adjust retentive areas. Once the final tilt of the cast is adjusted, the vertical arm indicates the path of insertion.

- Tilting the cast changes the height of contour for all teeth simultaneously.

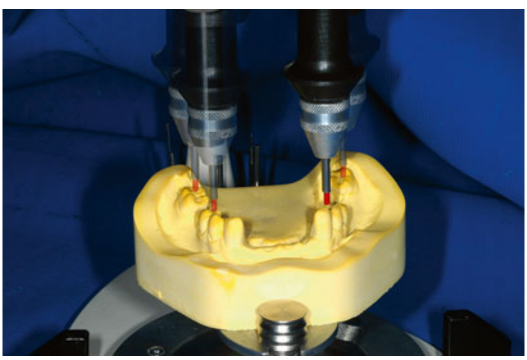


Fig. 14.2 Orientation of occlusal plane. Fix the cast holder when the distances between the occlusal surfaces and the vertical arm are equal

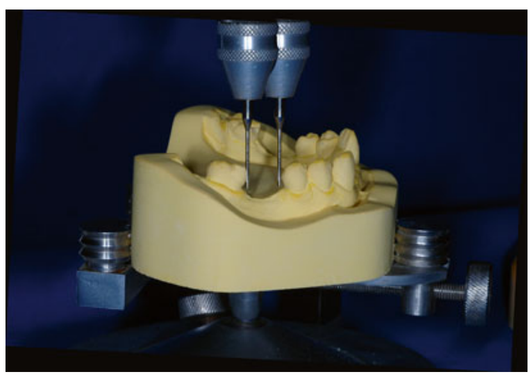


Fig. 14.3 The evaluation of axial surfaces in relation to path of placement

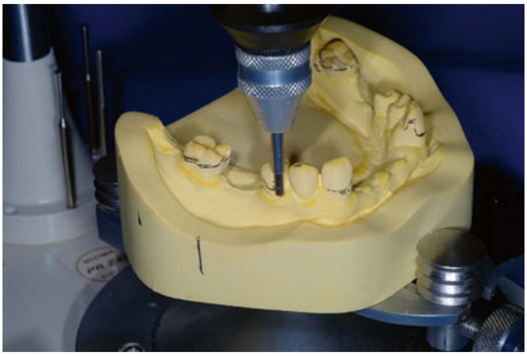


Fig. 14.4 Drawing the survey line. The carbon marker should travel on the most prominent circumference of the teeth. If the tip of the marker is drawing, then it is operating in the suprabulge area. If it is in contact with the gingiva and no survey line is drawn, then there is no retentive undercut on that particular tooth

3. Fix the cast position after allocation of undercuts and replace the analyzing rod with the carbon marker. Draw the survey line on all teeth (Fig. 14.4).

- It is the side of the marker that must contact the most prominent circumference of the teeth, not the tip. If the tip is marking the surface, it is probably working within the suprabulge area.
- In case a second survey line with an altered inclination of the cast needs to be drawn, different colored marking rods prevent confusion between different survey lines.

4. Replace the carbon marker with an undercut gauge.

They are conventionally available in three sizes as 0.25, 0.50, and 0.75 mm. The retentive tip of a cast clasp arm should be located in a 0.25 mm undercut; if the clasp arm will be of wrought wire then it may occupy a 0.50 mm depth. To use a 0.75 mm undercut, which is very rarely needed, the retaining arm should be made from wrought wire and be at least 8 mm long, otherwise it may apply excessive forces on abutment teeth during removal. Deeper undercuts can only be used with nonmetal clasp arms (see Chap. 12).

Use the appropriate gauge to locate the point of each abutment tooth that the retentive clasp arm will end and mark it with a pencil (Fig. 14.5a, b).

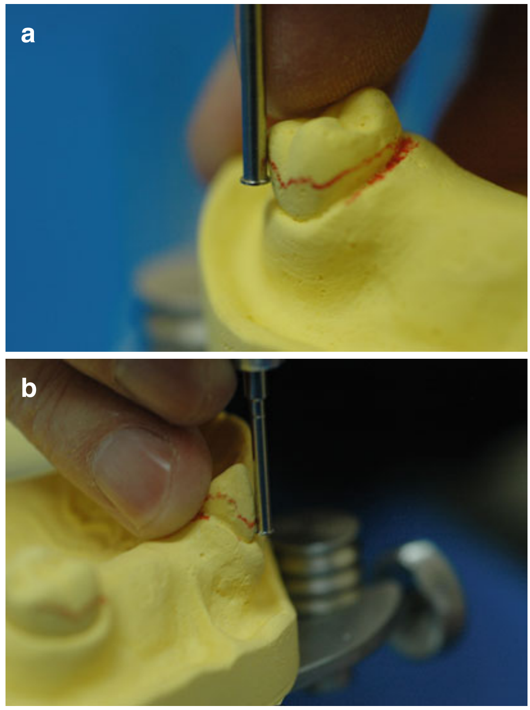


Fig. 14.5 (**a**, **b**) Determining the location of suitable undercut area. The undercut gauge contacts both the height of contour and point of desired amount of retentive undercut. (**a**) Location of the retentive arm tip for a circumferential clasp. (**b**) Location of the retentive arm for a bar clasp

14.2.3.2 Tripoding

Before removing the cast from the cast holder, its position should be recorded so that it can be remounted with the same path of insertion in the laboratory. This is referred to as "tripoding." Tripoding also allows the dentist to check the laboratory work.

If the cast is prepared appropriately, well trimmed, and shaped, three lines parallel to the path of insertion as a projection of the analyzing rod can be drawn. These three lines when paralleled on any surveyor reveal the determined path of insertion. It may be difficult to adjust the projections on the cast if it is not shaped properly (Fig. 14.6).

Another technique is to fix the vertical movement of the carbon marker at a specific height where it can make contact with three distant

Fig. 14.6 Tripoding by drawing parallel projections on the axial surfaces of the cast. These lines should be parallel to the path of insertion and should be drawn on three sides of the cast. In case two different paths are determined, they should be marked with different colored markers. The analyzing rod can be used as a ruler while drawing

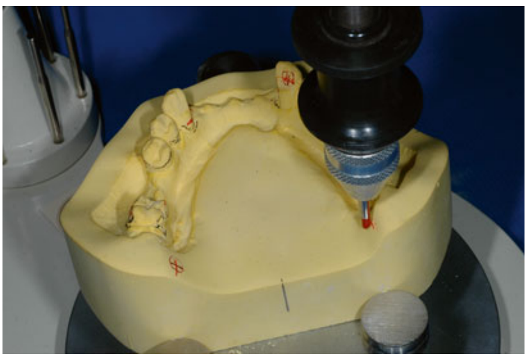


Fig. 14.7 Tripoding by marking three distant points on the cast. The vertical arm draws horizontal lines. Make vertical lines with a red pencil, intersect the two lines in their middle, and circle the + sign to locate the markings

points on the cast without interfering with the present drawings. Each of these points is marked with two short lines perpendicular to each other with the dot being at the junction and the formed plus sign encircled. The color of the pencil should be in contrast with the color of the plaster. When transferred to another surveyor, the height of the analyzing rod and the inclination of the cast are adjusted to provide the same contacts between the three points and the tip of the rod. Like the other method, the adjustments may take some time to achieve accurate alignment (Fig. 14.7).

A flat shaft or a simple handpiece bur can also be used to tripod the cast. A small cavity, a little larger than a bur shaft and about 5–10 mm in depth, is drilled on an available location on the cast. The flat shaft or the bur is mounted on the vertical arm, naturally in exact alignment with the path of placement. The drilled cavity is filled with either a few drops of plaster or acrylic resin, and the mounted shaft is placed and fixed in contact with the bottom of the cavity. After the filling material is set, the vertical arm is detached and the rod left on the cast which can now be mounted on any surveyor without error very easily (Fig. 14.8a–c). There are even commercially available pins to apply with this technique.

14.2.3.3 Evaluation of Potential Abutment Teeth

Surveying reveals options in defeating any obstacles to benefit from abutment teeth for retention, reciprocation, stabilization, and path of placement. These options include:

- Minor grinding of teeth
- Adhesive restorations
- Fixed prosthesis
  - To integrate the tooth into the definitive design
- Extraction
- Ignoring
  - To create a design without involving a particular tooth

Guiding Planes/Guiding Plates

Axial walls of abutment teeth, sometimes along with reciprocating surfaces, guide the prosthesis from the initial contact with the teeth to the final seating through the defined path of placement. The potential guiding surfaces are evaluated with the surveyor and adjusted if necessary.

Once the path of insertion is decided, if the height of contour on a desired guiding surface appears to be narrow and close to the plane of occlusion (within the occlusal 1/3 of the abutment teeth), the surface can be altered with a simple grinding to create a proper guiding plane

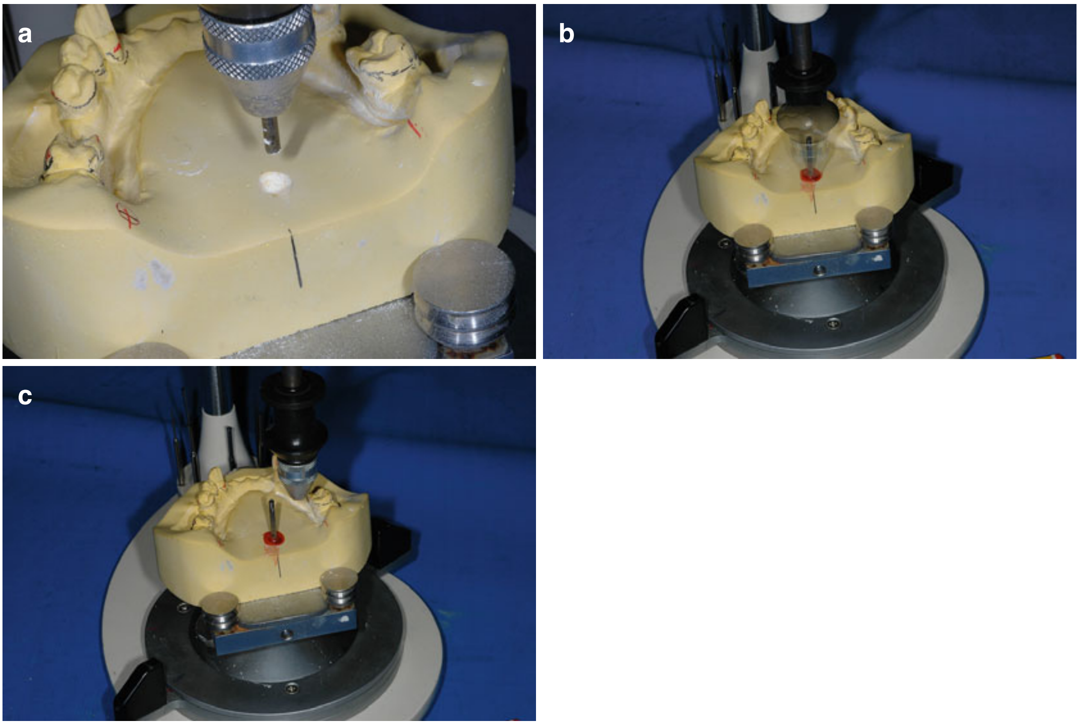


Fig. 14.8 (**a–c**) Tripoding by embedding a straight rod in the surveyed cast. (**a**) A hole is drilled on the cast and the rod is attached to the vertical arm. (**b**) The cavity is filled with acrylic resin and the rod is fixed in contact with the bottom of the cavity. (**c**) The vertical arm is detached and the rod is aligned with the path of placement

covering nearly 1/3 of tooth height and bearing a smaller dead zone close to the gingiva. Grinding of the diagnostic cast on the surveyor will be the reference to the preparative clinical procedure.

Retention

In case the amount of retentive undercut is not sufficient or there is no undercut at all on a particular tooth which otherwise is a potential abutment, the ability to provide retention should be added. It is possible to correct the position of tipped or rotated teeth with orthodontics; however, it mostly is not practical due to added cost and time to finish the overall treatment. A common solution is recontouring of the teeth to create an undercut area either by grinding the enamel surface or with an adhesive restoration. If one of these options is not capable of handling the situation, then we are left with the choice of a full crown restoration. Occasionally, extraction of a severely malpositioned tooth may be necessary when its existence interferes with any proper design alternatives of the framework.

Conversely, when the survey line is too high and/or the retentive undercut is sharply too deep to allow a proper clasp design, the tooth can be altered to serve efficiently with one of the options above.

Reciprocation

One of the overlooked issues regarding clasp design is the establishment of reciprocation. A reciprocal component can reciprocate the action of the retentive arm either if it contacts the abutment tooth before the retentive arm or if they make the initial contact simultaneously. Furthermore, it should continuously keep its contact while the retentive arm slides over the survey line until the framework is fully seated. This requires a flat surface that is parallel to the path of insertion and as wide as the vertical travel of the clasp tip from its initial contact to final seating. This flat surface almost never exists on natural teeth.

The reciprocating surfaces of the teeth should be integrated to the path of insertion either by grinding or a restorative alternative.

14.2.3.4 Grinding the Diagnostic Cast

The controlled grinding of tooth surfaces on the surveyor can be done with the help of undercut gauges.

When the analyzing rod slides almost in contact with the potential retentive surface but reveals no suitable undercut area, grinding within the enamel layer may be the solution. The desired location of the clasp tip is marked with a pencil with the help of the analyzing rod visual. The manual grinding of the plaster surface can be done with a round-tipped modeling knife until the 0.01 in. gauge fits the undercut that is carved. This provides sufficient retention for a cast metal clasp arm without removing excessive amounts of tooth structure.

The guiding planes can also be arranged with the help of undercut gauges. The marking rod is replaced with a 0.01 in. undercut gauge, and the point where the gauge contacts the plaster on the axial surface is marked with a pencil. The grinding of the surface, parallel to the path of insertion, can be done with the carving knife of the surveyor. The procedure can be repeated if sufficient width of plane is not achieved. Even if a third carving is needed, the amount of lost enamel width will correspond to 0.03 in., which is often possible without exposing any dentin tissue.

With the path of insertion decided and possible preparations carried out, the design of the framework should be studied on the diagnostic cast.

The final shape of the diagnostic cast is the reference to alterations, which has to be made in the mouth. There are several methods to guide clinical procedures to imitate the changes on the study cast, but usually the simple marks drawn on the cast are sufficient. Having worked on the study cast, the dentist can easily repeat similar preparations in the mouth before making the final impression.

The final analysis is made on the master cast with the same order. After the survey line is drawn, the design of the metal framework can be transferred to the master cast.

14.3 Laboratory Procedures

14.3.1 Final Casts: Mounting in the Articulator and Diagnostic Wax-Up

The model is cast with Class IV superhard stone (Fig. 14.9). In our lab, the occlusal surface of the opposing impression is constructed with polyurethane (Fig. 14.10). This material is more resistant to abrasions than plaster but less precise and is more heat sensitive.

A mounting table helps in mounting the models on the Gerber articulator (Fig. 14.11).

As it is not always easy to establish occlusal vertical dimension once the models are in the

Fig. 14.9 Model cast with super stone Class IV

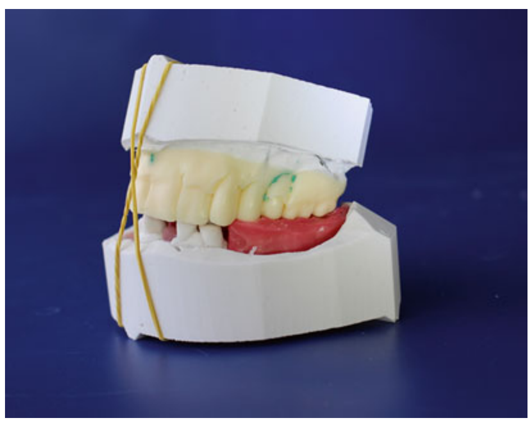


Fig. 14.10 Centric record: The occlusion rim should not overlap the first molar

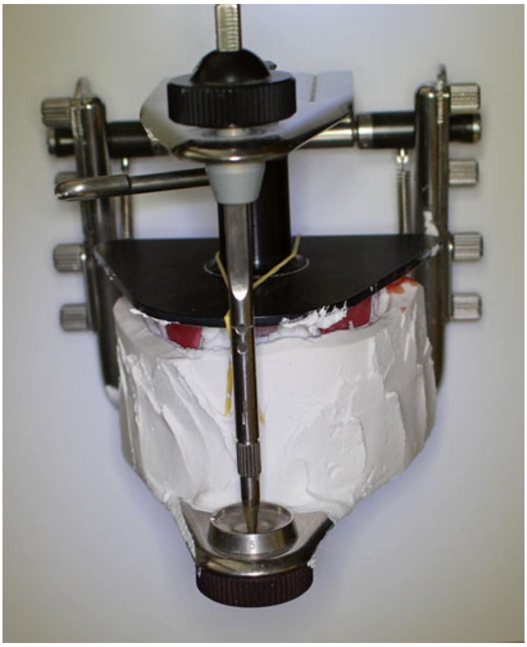


Fig. 14.11 Lower cast is mounted on the Gerber articulator

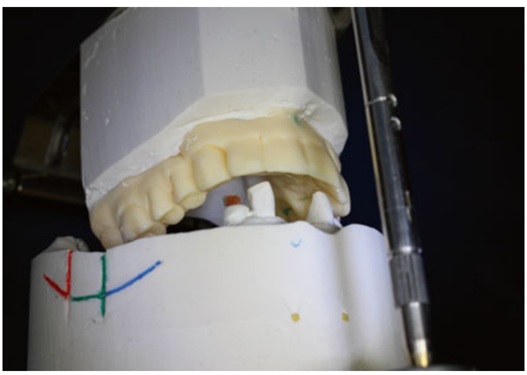


Fig. 14.12 Vertical height according to the centric record by the clinician

articulator, a diagnostic wax-up may be helpful to readjust the occlusal vertical dimension (Figs. 14.12, 14.13, and 14.14).

14.3.2 Model Analysis: Mounting of the Posterior Teeth

Overlay constructed frameworks are still common. It is preferable to work with a minimum of clasps for hygienic reasons. There is always a

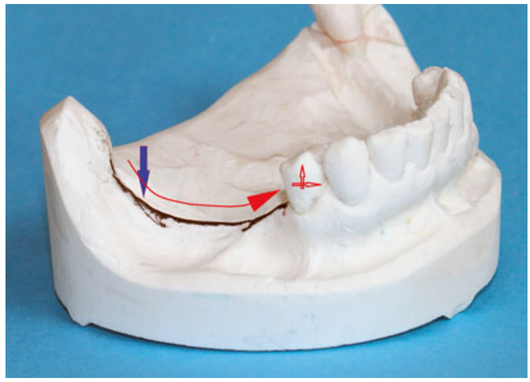


Fig. 14.13 The blue arrow represents the chewing pressure in the area of the last molar. If chewing force occurs on this tooth, the resulting force produces pressure in the direction of the red arrow

Fig. 14.14 The last molar is placed over a steep surface. The resulting chewing force (*black arrows*) can damage the ball attachment on the root of the canine

risk of secondary caries and periodontal problems occurring underneath the clasps.

14.3.2.1 Occlusion: Sagittal Stability

An inadequate occlusion may produce horizontal forces (Figs. 14.13, 14.14 and 14.15) which could cause periodontal problems and ultimately the loss of the anchor tooth.

To prevent undesired horizontal forces on lower cases, examine the alveolar ridge, and mark a red vertical line indicating the anterior limit of the posterior areas which are provoking the horizontal forces. No tooth should be in occlusal contact beyond this line. The deepest place for the first molar is marked with a green line (Fig. 14.16).

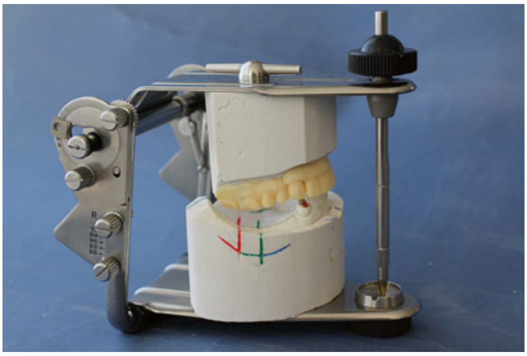


Fig. 14.15 The model analysis is executed with the models placed on the Gerber Condylator

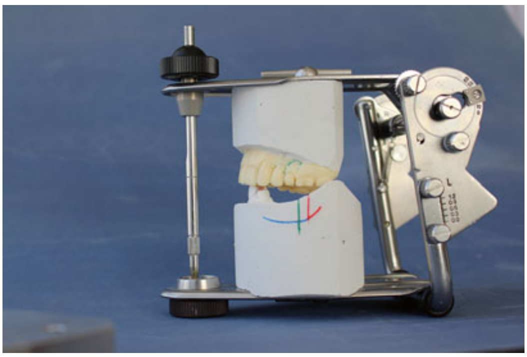


Fig. 14.16 The model analysis on the left side can be different from the right side

The setup is made before the fabrication of the cast metal frame and follows the model analysis (Figs. 14.16, 14.17 and 14.18).

14.3.2.2 Occlusion: Transversal Stability

With free-end saddles, the anteroposterior line of the occlusal contact originates from the last tooth or root with an attachment, and its posterior support is the alveolar ridge (Figs. 14.19 and 14.20). Forces occurring outside the center of the alveolar ridge produce torsion on the free-end saddle and can overload the anchor tooth. The use of the lingualized occlusal concept offers a good solution for keeping the occlusal forces as close as possible to the anteroposterior line (Figs. 14.21 and 14.22).

Position of the upper molar in a lingualized occlusion is shown in Fig. 14.22. The buccal cusp is out of contact by 2 mm.

The lingualized occlusion is recommended for upper partial dentures with free-end saddles, based on the same principle as shown in Figs. 14.19, 14.20, 14.21, and 14.22 for lower partials.

Different cases require different types of occlusal relations. These are explained in Chap. 13, "Establishing Occlusal Relationships."

Figs. 14.17 and 14.18 Setup of posteriors according to the model analysis

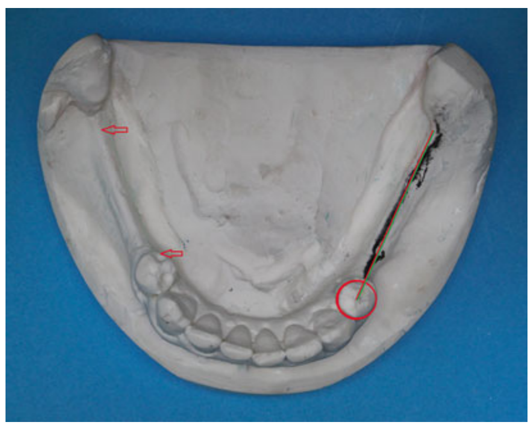


Fig. 14.19 On the left side of the case, the center of the alveolar ridge is marked with a lead pencil leading to the anchor tooth (*red circle*). On the right side the *arrows* indicate the borders of the line which will be drawn through the center of the ridge to the anchor tooth

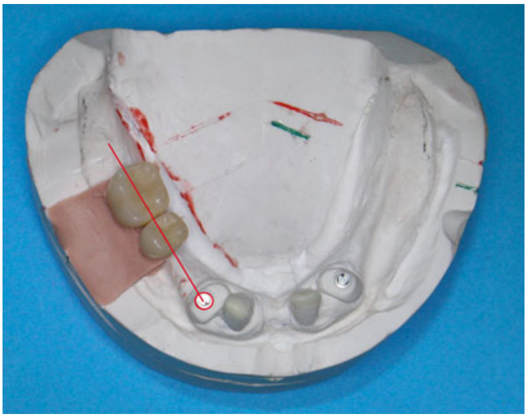


Fig. 14.20 In a case with attachments and free-end saddle, the center of the supporting alveolar ridge crosses over the center of the lower teeth

Fig. 14.21 Control of the position of the molar in relation to the alveolar ridge. The tooth is not obstructing the space for the tongue and will get a tight contact to the buccinator muscle

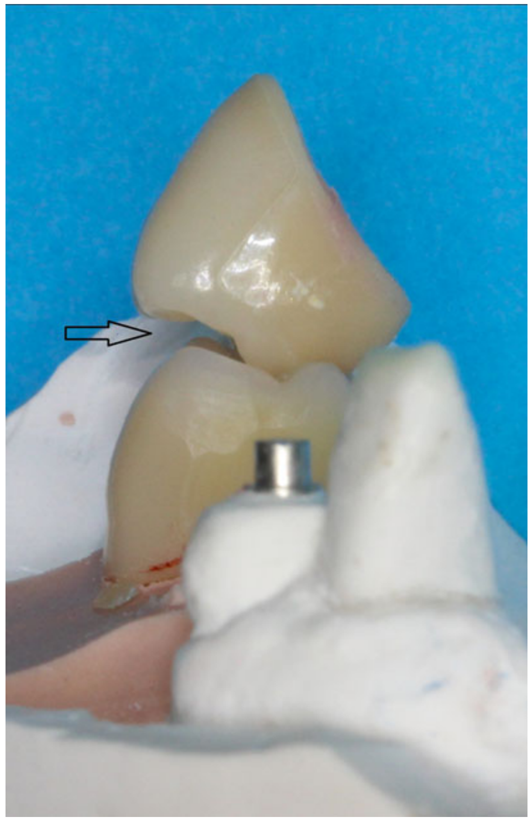


Fig. 14.22 Position of the upper molar in a lingualized occlusion. The buccal cusp is out of contact by 2 mm

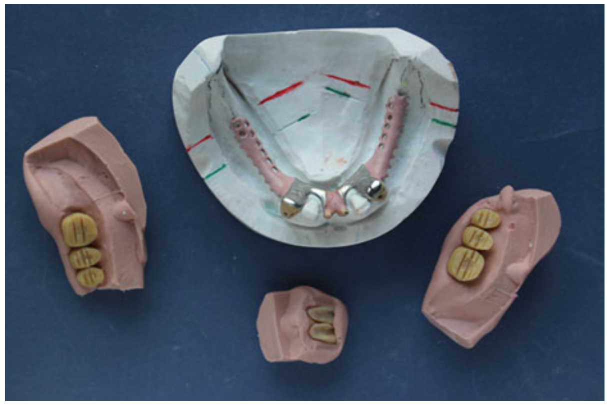
Fig. 14.23 Once aesthetics and occlusion are satisfactory, plaster or silicone keys are made over the teeth

14.3.3 Try-In and Preparation for the Cast Metal Frame

Aesthetics and occlusion must be established first and tried in before building the metal framework (Fig. 14.23). This way the metal form can be precisely designed and the retention for the artificial teeth positioned where needed without disturbing the aesthetics of the case (Figs. 14.24 and 14.25).

If artificial anterior teeth are part of the case, a new try-in is recommended once the metal framework has been completed.

After final try-in, the work is sent to the dental lab for finishing procedures.



Figs. 14.24 and 14.25 Grooves are cut outside the casting. The grooves assist in repositioning the keys when remounting the teeth once the metal frame has been completed. Especially for aesthetics, it is recommended to repeat the try-in when anterior teeth are prepared

Fig. 14.26 First drawing on the first model

14.3.3.1 Planning

Well-thought-out plans avoid complication. This involves a collaborative effort between clinician and laboratory technician. The technician should be informed of which teeth are solid and able to support the load of the partial denture and which teeth must be avoided or only stabilized by including them in the metal frame.

The planning begins with surveying and making a simple drawing on the diagnostic model (Fig. 14.26). After mouth preparation the master cast is surveyed, tripoded, and delivered to the lab with the desired design transferred to the final cast. Important information can be drawn in the work authorization form as seen in Fig. 14.27.

14.3.3.2 The BIOS System

The form of the BIOS clasp is different and offers better precision to determine the force of retention. Because the clasp arm of the BIOS system is symmetrical and progressively conic (Fig. 14.28), its diameter is like a wire cut in half (Figs. 14.29). The diameter of clasps for the Ney system is ovoid with a flat surface. In the mouth, the BIOS clasp is less visible (Fig. 14.30a, b) and diminishes the risk of secondary caries.

14.3.3.3 Construction of the Metal Framework

Construction of the framework is conventionally done by casting (Fig. 14.31). Cr-Co alloys are regularly used for the purpose. Titanium is an alternative which is lighter and more flexible than Cr-Co and reveals better results with CAD-CAM manufacturing. Due to these properties, it is less possible for titanium frameworks to show plastic deformation, but their flexibility endangers the acrylic-metal base connection. Breaking of the acrylic saddles may be expected. However, a 2-year clinical study showed no significant difference between the clinical successes of the two materials.

CAD-CAM and laser-sintering techniques are modern production techniques (Fig. 14.32). The digital production of the framework needs the transfer of the framework design to the computer media; therefore, plastic patterns are used to make the prototypes. Digital systems show better

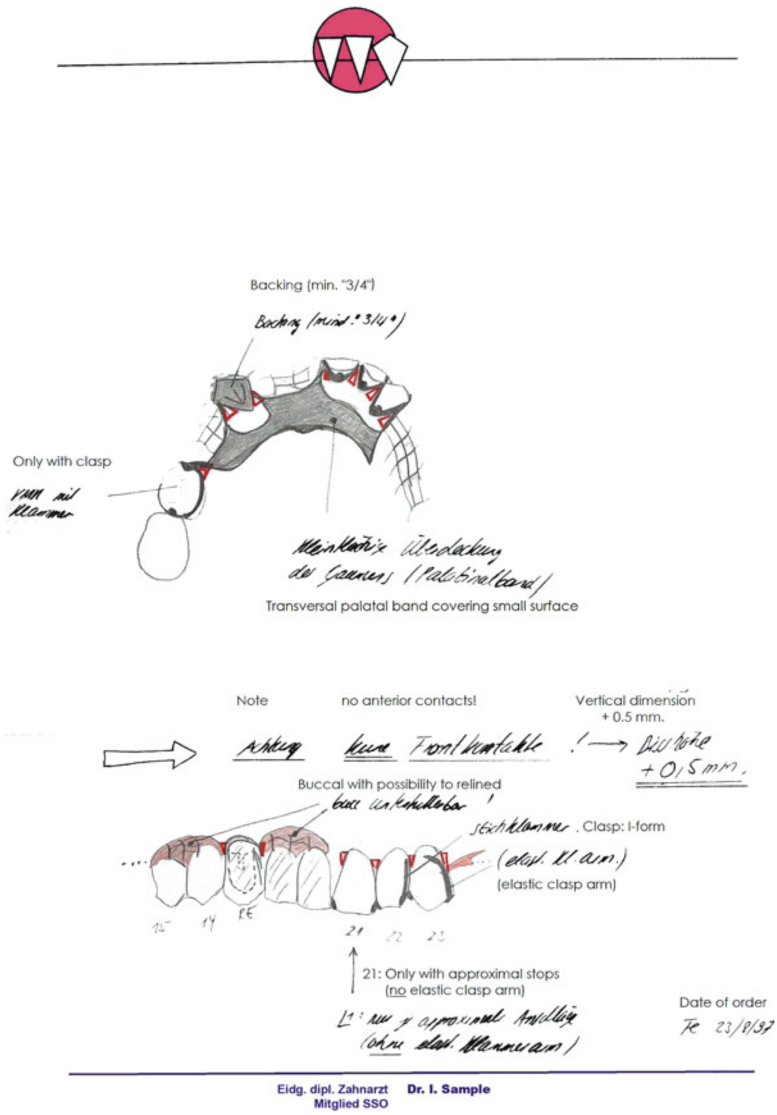


Fig. 14.27 A typical example of a hand-written "work authorization form" including the details of the framework as the dentist designed it and all complementary information that the clinician sends to the laboratory. It is more descriptive when the written instructions are associated with a detailed drawing of the case and the design

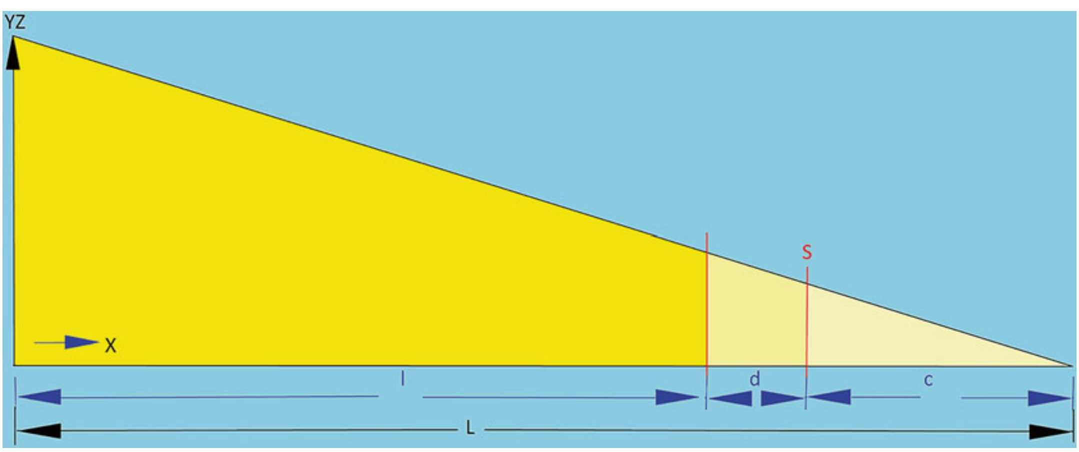


Fig. 14.28 If the clasp arm is shortened then it will be less flexible

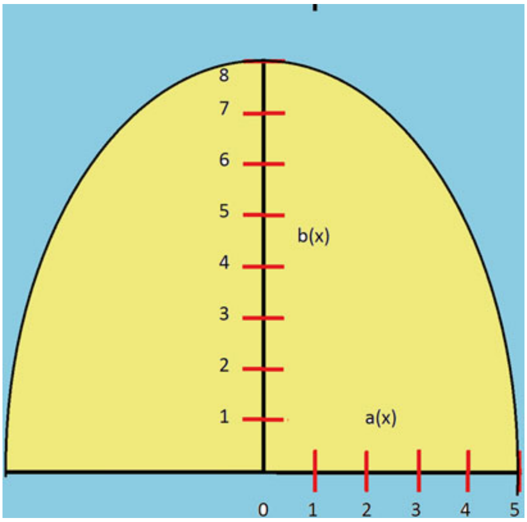


Fig. 14.29 This is the diametric form of a BIOS clasp. It is less visible (aesthetics) and the contact surface to the natural tooth is small (risk of secondary caries is diminished)

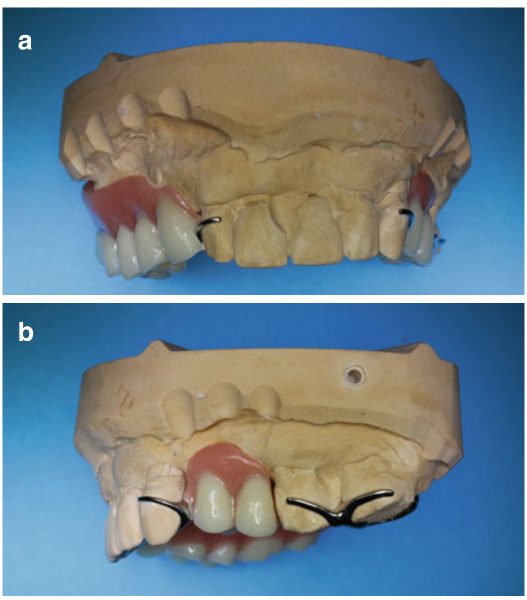


Fig. 14.30 (**a**, **b**) The clasps are very fine but offer the same strength and flexibility as the common clasps

dimensional stability when compared to casting but are more expensive. The nature of laser sintering is more suitable to the complex design of frameworks which is harder with CAD-CAM technique, as the first one builds up the structure in layers melting each one over the other with a laser beam while the latter grinds from a block of material mechanically.

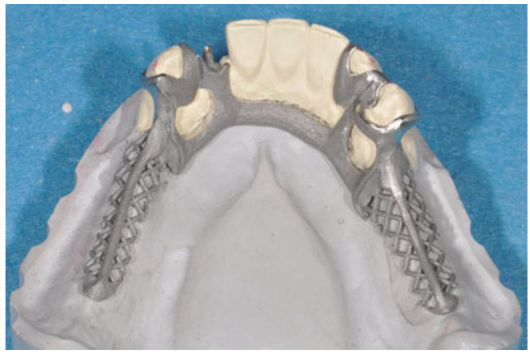


Fig. 14.31 Cr-Co framework constructed by conventional casting

Fig. 14.32 Metal frameworks produced by laser sintering

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Initial Placement and Adjustments 15

Tonguç Sülün

15.1 Definitions

Bruxism 1) The parafunctional grinding of teeth; 2) An oral habit consisting of involuntary rhythmic or spasmodic nonfunctional gnashing, grinding, or clenching of teeth, other than chewing movements of the mandible, which may lead to occlusal trauma

Centric stop Opposing cusp/fossa contacts that maintain the occlusal vertical dimension between the opposing arches

Denture border 1) The margin of the denture base at the junction of the polished surface and the impression surface; 2) the peripheral border of a denture base at the facial, lingual, and posterior limits

Disclusion Separation of opposing teeth during eccentric movements of the mandible

Pressure-indicating paste Any substance applied to a dental prosthesis, which, when seated on a structure, demonstrates the adaptation of the prosthesis to the structure it opposes

Clinicians mostly underestimate the appointment for the delivery of RPDs. However this appointment is as significant as other procedures. Thus it is important to offer sufficient time and effort for this appointment.

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15.2 The Timing of Delivery Appointment

1. The delivery of the prosthesis should be early in the morning to have time for a double check after the patient used the RPD for several hours.
2. This appointment should not be placed in the last day of the week. It is important to give the patient the chance for a second appointment the day after. Although the patient has no complaints with the denture or can remove the prosthesis for one day if any, patients mostly favor to see the dentist immediately.

15.3 The Goals of Delivery Appointment

15.3.1 Making the Insertion of the RPD Comfortable by Adjusting the Clasp Arms, Overpressure Points on the Impression Surface, and Overextended Borders

Normally checking and adjusting the framework should have been done at the previous appointment. Therefore, this procedure takes a short time. The fit of the RPD will not be proper if the undercut areas in soft tissue weren't correctly

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blocked out by the dental technician or if too much polymerization shrinkage occurred. In these cases, the metal framework can't be seated exactly on the abutment teeth. Thus, not the framework but the intaglio acrylic surfaces should be analyzed. Also, the retention of the RPD can be too strong or too weak due to the messy job of the dental technician. The clasp arms should be adjusted accordingly using a proper clasp-bending pliers.

After this procedure, if the RPD still doesn't fit properly, the guiding surfaces of the framework should be checked. In most cases, an excessive acrylic on this surface is responsible for the lack of fit of the RPD. Indicator material, articulating paper, or occlusion sprays can be used to detect the place which blocks the path of insertion (Fig. 15.1a–c).

The fit of the RPD will not be correct if any overpressure points on the impression surface or overextended borders are there. To detect the pressure points, the best method is using pressure-indicating paste. To apply the paste on the impression surfaces correctly, the base should be dried before. A stiff-bristled brush is used to coat the surface with a thin layer of pressure-indicating paste. The brush marks should be visible (Fig. 15.2). Before applying in the mouth of the patient, the prosthesis is best sprayed with silicone oil to avoid sticking the paste to the oral mucosa. The RPD is then placed in the mouth carefully, and the patient is asked to bite on a cotton roll gently for a few seconds. If the paste has lost the brush marks and a tissue pattern is visible, the fit of the base with the mucosa is correct. If the brush marks are still there in some places,

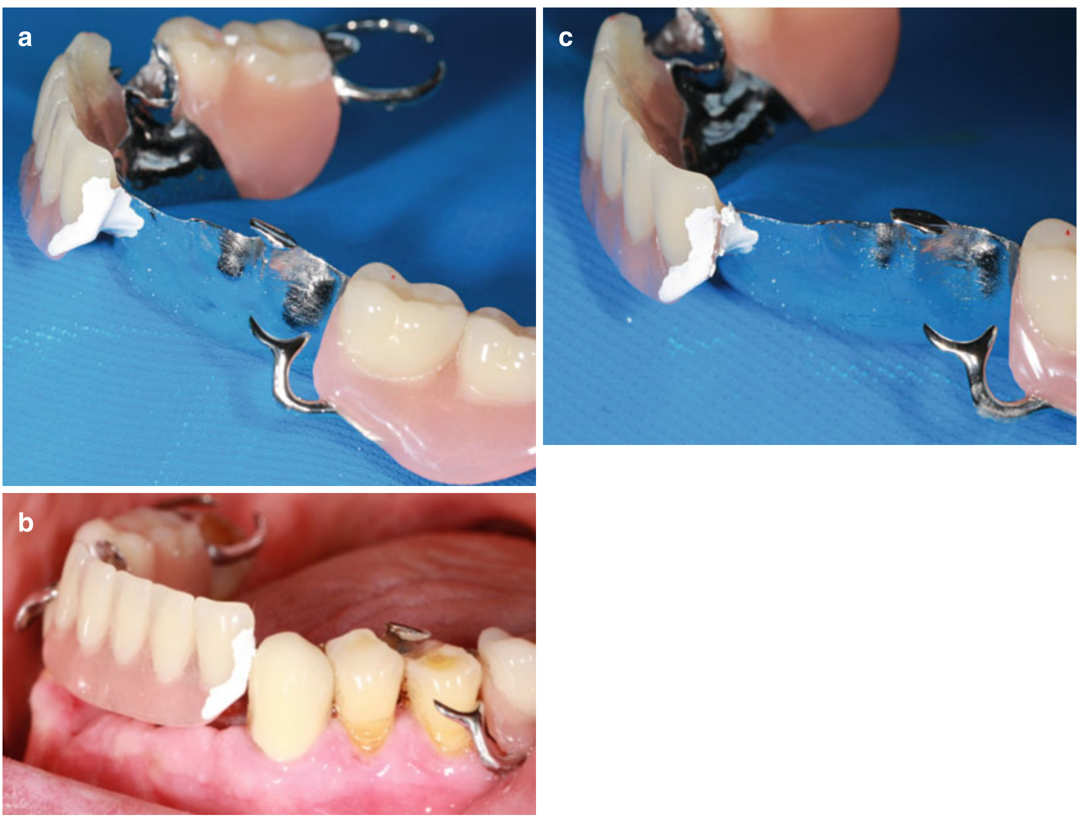

Fig. 15.1 Mandibular prosthesis is not seated correctly to the place. (**a**) The guided surface is painted with a thin layer of indicator material. (**b**) The prosthesis is forced to be placed in the mouth of the patient. (**c**) The indicator material is scratched over the acrylic surface. The part is then grinded carefully

there is no contact in these parts of the base (Fig. 15.3). And if there is no paste anymore on some areas, these are the overpressure points and should be adjusted before the delivery of the prosthesis to the patient.

The overextended borders of the prosthesis should be also adjusted before the delivery. This can worsen the retention of the RPD or can cause ulceration in the soft tissue. A visual examination during functional movements of the patient is mostly enough to detect the overextended border. However, sometimes it is very difficult to identify the exact place. Thus, using a heavy-body silicone impression material will be helpful in detecting the part that needs to be shortened. A thin coat of silicone material is placed on the tissue surface of the RPD. After that, the patient makes functional movements. The impression material is easily wriggled out from the extended border. This part is then shortened accordingly.

15.3.2 Checking the Aesthetics of the Prosthesis and Making Individualization by Cosmetic Grinding

The aesthetic try-in procedures are not so difficult in RPD treatment compared with complete dentures or FPDs. Most RPDs are prepared to replace

Fig. 15.2 The impression surface of the prosthesis is painted with pressure-indicating paste (PIP)

Fig. 15.3 Notice the overpressure point in the pressure-indicating paste (PIP)

the posterior teeth. However, in cases with lack of anterior teeth, individualization of the prefabricated teeth is mostly necessary. Nowadays there are plenty of individualization composite sets in the dental market. If porcelain teeth were used, a conventional technique can be used. It is also important to note that if a crown restoration for the abutment tooth was planned, the selection and arrangement of the artificial teeth should be prepared before the aesthetic work of the crown was finished. It is the easiest way to achieve the best aesthetic harmony between prefabricated teeth and crown restoration. The dental technician makes the aesthetic labial surface of the crown according to the artificial teeth. Otherwise, it will be quite difficult to achieve an aesthetic result in a combined prosthesis.

15.3.3 Adjusting Centric and Eccentric Occlusion

Prior to the delivery of the prosthesis to the patient, the clinician must be sure that the occlusion is perfect. It is unexpected that the metal framework disturbs the occlusal balance. The contacts of the occlusal rests with the antagonist teeth have to be checked before. However, if the fit of the RPD is not ideal, a gap between the occlusal rest and seat may be seen easily. Thus, in such a case, the fit of the RPD should be checked again.

The most expected problem with the occlusion is the premature occlusal contacts of the prefabricated teeth on RPD. This problem can be solved easily by systematic occlusal grinding in the mouth. However, in cases with huge premature occlusal contacts or disclusion of the posterior artificial teeth, the best way is to remount the prosthesis to the articulator and to make the corrections in the dental laboratory. The best method is to take a new centric record using a silicone bite registration material and impression compound. The impression compound is softened first and applied on the maxillary incisors to create a deprogrammer. After the deprogrammer is hardened, the contact of the mandibular incisors with the flat surface of the compound is checked.

Fig. 15.4 The occlusion of the prosthesis is not sufficient. Thus, a centric record is made

This surface should be prepared perpendicular to the long axis of the lower incisors. A disclusion of 2–3 mm. between the posterior teeth in centric and eccentric occlusion is ideal to make a centric registration. After that, silicone bite registration material is applied between the posterior teeth (Fig. 15.4). Following alginate impressions of both jaws are taken (Fig. 15.5). The RPD should stay within the impression. A remount cast is formed after all undercut places, clasps, and proximal plates are blocked out with wax. These remount casts are then transferred to an articulator using the interocclusal record (Fig. 15.6a–c). The occlusion is corrected and the RPDs placed to the mouth of the patient (Fig. 15.7).

Occlusal grinding of the artificial teeth is a very easy process and similar to the method used for complete dentures.

15.3.4 Instructing the Patient How to Maintain the Prosthesis, the Mouth, and the Remaining Teeth

First of all, the patient should be informed about the importance of path of insertion. The patient should understand that his/her prosthesis can be inserted and removed in only one direction.

Fig. 15.5 Alginate impressions are made for the lower and upper jaws

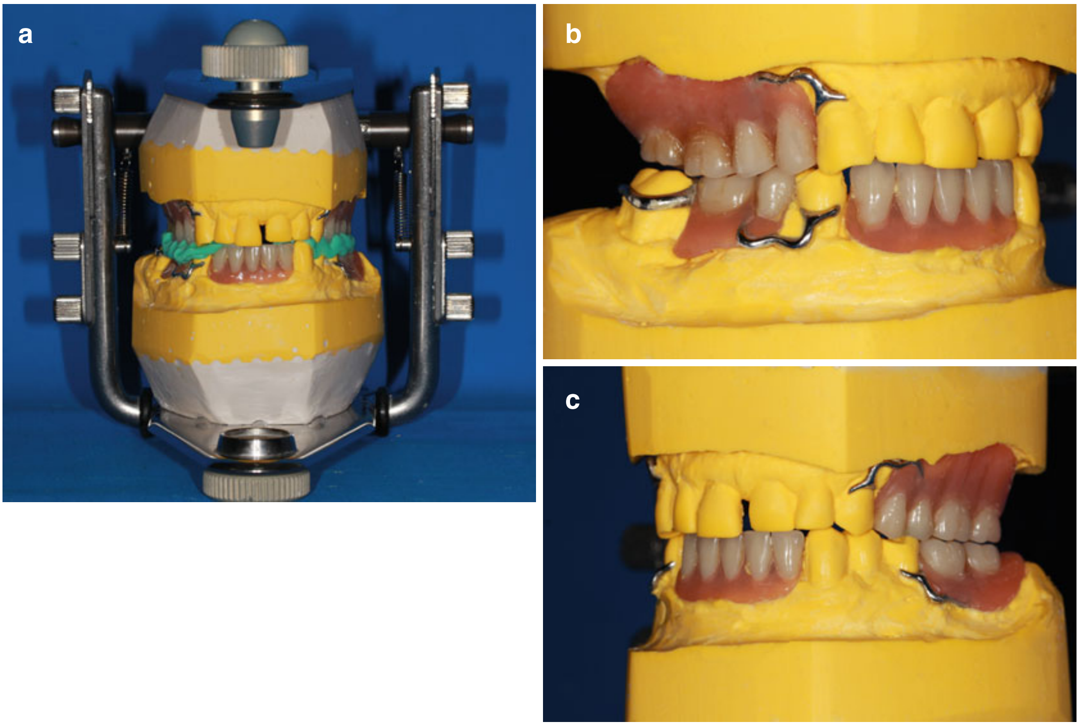

Fig. 15.6 (**a**) The remount casts are mounted to the articulator. (**b**) There are no occluding contacts (*right side view*). (**c**) There are no occluding contacts (*left side view*)

Therefore, the first insertion and removal of the RPD should be performed by the clinician while the patient observes the process. After that, the mirror is held by the doctor and the patient tries carefully to insert and remove the RPD into the mouth. The patient should be warned not to place the prosthesis by biting on it but instead to guide it into the seated position when the balls of the fingers are on the clasps of the prosthesis. The patient should secure the perfect seat of the prosthesis by applying pressure along the incisal and/or occlusal surfaces of the artificial teeth.

Fig. 15.7 The adjusted prosthesis in the mouth of the patient. Notice the restored left central tooth, too

For the removal of the prosthesis, the patient should use the thumbnails for the mandibular RPD and the index fingers for the maxillary RPD. The force should be applied to the clasp shoulders equally for both sides. Applying the force directly to the terminals can result in the distortion of the clasp arms. Trying to remove the prosthesis from the acrylic is not recommended because of the risk of mucosal irritation. There is, however, no other way to remove the RPDs with precision attachment. As a solution, a metal pin is constructed in the framework which is covered then with acrylic resin, and only the tip stays on the polished surface of the RPD. This is a good retentive part to apply force with the fingernails. However, patients find these parts mostly irritating. Another way to remove the RPDs with precision attachment is holding the prosthesis using the thumb and index fingers of the same hand.

It is crucial to inform the patient that the prosthesis and the teeth should be kept clean. The patient must understand that lack of hygiene is more hazardous for the development of caries when using an RPD. Especially the areas between minor connectors and oral tissues are prone to food accumulation. A normal stimulation of tongue and food contact is lacking in these areas. Therefore, the patient should give extra effort by using a toothbrush to simulate normal function. The patient should be informed not to use toothpaste for cleaning the RPD. Toothpastes contain mostly abrasive particles which can easily damage the acrylic surfaces of the denture. A denture-cleaning solution can be used for extra cleaning especially for older and handicapped patients. Soaking the prosthesis 15 min daily in this solution helps not only to keep the denture clean but also to disinfect the surfaces.

Despite every effort of the dentist, the character, age, neuromuscular adaptation capability, and expectations of the patient make it sometimes very difficult to adapt to the new denture. Thus, the patient should be informed of the possible discomfort in the first few days, e.g., soreness, difficulty with phonetics, discomfort, and gagging. Patients mostly like to know that these difficulties can be solved easily in the control appointments. It is vital to inform the patients about the importance of periodic recalls.

Night wear of the prosthesis is a controversial issue in current dental literature. Because of hygienic reasons and from a physiological point of view, it is better to take the prosthesis out at night. However, in cases with severe bruxism, it is better to advise the patient to keep the prosthesis in the mouth while sleeping because of the better distribution of the occlusal loads. Another example is the typical patient with maxillary complete denture and mandibular RPD. These patients mostly like to wear his or her complete denture at night. If the patient is insistent about this routine, it is better to advise the patient to wear also the mandibular prosthesis. Otherwise the risk of the resorption of the anterior part of the maxillary crest will be higher.

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Part IV

Advanced Retention and Support Auxiliaries for Removable Partial Dentures

Attachments and Double Crown Systems for Removable Partial Dentures

16

Ahmet Altuğ Çilingir

There is lack of evidence-based knowledge to dominate clinical decision-making about attachments for RPDs. Even though the use of attachments in clinical dentistry is very regular, selecting the appropriate attachment for a particular case can sometimes be a challenge. In this chapter, a brief classification of attachments, attachments' resilience capacities, step-by-step detailed clinical cases and clinical hints in decision-making are explained.

16.1 Definitions

Attachment (1) A mechanical device for the fixation, retention and stabilization of a prosthesis; (2) a retainer consisting of a metal receptacle and a closely fitting part; the former (the female {matrix} component) is usually contained within the normal or expanded contours of the crown of the abutment tooth, and the latter (the male {patrix} component) is attached to a pontic or the denture framework.

Frictional Attachment A precision or semi-precision attachment that achieves retention by metal to metal contact, without springs, clips or other mechanical means of retention.

Precision Attachment (1) A retainer consisting of a metal receptacle (matrix) and a closely fitting part (patrix); the matrix is usually contained within the normal or expanded contours of the crown on the abutment tooth/dental implant, and the patrix is attached to a pontic or the removable dental prosthesis framework; (2) an interlocking device, one component of which is fixed to an abutment or abutments, and the other is integrated into a removable dental prosthesis in order to stabilise and/or retain it.

Semi-precision Attachment A laboratory-fabricated rigid metallic extension (patrix) of a fixed or removable dental prosthesis that fits into a slot-type keyway (matrix) in a cast restoration, allowing some movement between the components.

Precision Rest A prefabricated, rigid metallic extension (patrix) in a fixed or removable dental prosthesis that fits intimately into the box-type rest seat or keyway (matrix) portion of a precision attachment in a restoration.

Resilient Attachment (1998) An attachment designed to give a tooth-borne/soft tissue-borne removable dental prosthesis sufficient mechanical flexion to withstand the variations in seating of the prosthesis due to deformations of the mucosa and underlying tissues without placing excessive stress on the abutments.

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Intracoronal Attachment Any prefabricated attachment for support and retention of a removable dental prosthesis. The male and female components are positioned within the normal contour of the abutment tooth.

Extracoronal Attachment Any prefabricated attachment for support and retention of a removable dental prosthesis. The male and female components are positioned outside the normal contour of the abutment tooth.

Overdenture Any removable dental prosthesis that covers and rests on one or more remaining natural teeth, the roots of natural teeth and/or dental implants; a dental prosthesis that covers and is partially supported by natural teeth, natural tooth roots and/or dental implants – called also overlay denture, overlay prosthesis or superimposed prosthesis.

Telescopic Crown An artificial crown constructed to fit over a coping (framework). The coping can be another crown, a bar or any other suitable rigid support for the dental prosthesis.

Precision attachments offer aesthetic solutions to patients who are not satisfied with the appearance of their conventional removable partial denture (RPD). An attachment should replace the functions of a direct retainer. Basically, it should provide support, stabilisation and retention; therefore, it should be designed to have specific parts acting instead of an occlusal rest (1), a reciprocal arm (2) and a retentive arm (3) (Fig. 16.1).

Attachments are divided into two main categories as precision and semi-precision attachments. Precision attachments are manufactured precisely from a special metal alloy at a level of 0.01 mm tolerance. Matrix and patrix are both prefabricated and have some advantages such as ease of changing the parts when necessary and exhibition of less wear as compared to semi-precision attachments. On the other hand, the main disadvantage of using precision attachments is the high cost. Semi-precision attachments are fabricated using wax, plastic or refractory patterns. These patterns are attached to wax patterns of crowns or removable partial denture frameworks and are cast together with various metal alloys. Conventional casting procedures may affect the precision negatively, and therefore these attachments are called "semi-precision" attachments. Easier fabrication, lower cost and absence of welding are the main advantages of semi-precision attachments.

16.2 Classification of Attachments

There are two different main classifications according to function and location of the attachments. RPDs transfer occlusal forces to supporting tissues like teeth and alveolar bone by their structural components. Resilient attachments transfer occlusal loads to alveolar tissues better than non-resilient attachments.

Non-resilient attachments, theoretically, do not allow any movement between their parts. However, slight amount of movement will occur after wear of the components.

16.2.1 Classification of Attachments According to Their Function

One of the most important issues in planning an attachment-retained RPD is to decide the type of attachment. The length of the edentulous

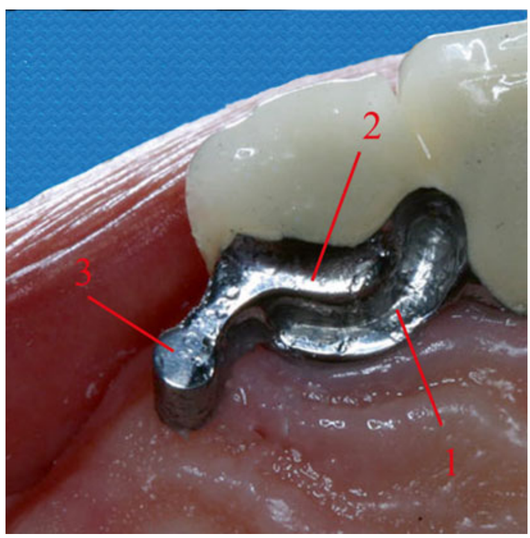

Fig. 16.1 An attachment should have parts of a direct retainer assembly. (*1*) An occlusal rest, (*2*) a reciprocal arm and (*3*) a retentive arm

space, Kennedy classification of the partial edentulism, periodontal health of abutment teeth and oral hygiene status of the patient should be taken into account while deciding the type of attachment.

Solid Attachments

Class 1a Solid, rigid, non-resilient (Fig. 16.2)

Class 1b Solid, rigid, non-resilient, lockable with an extra part (Fig. 16.2)

Resilient Attachments

Class 2 Vertical resilient (Fig. 16.3)

Class 3 Hinge resilient (Fig. 16.4)

Class 4 Vertical and hinge resilient (Fig. 16.5)

Class 5 Rotational and vertical resilient (Fig. 16.6)

Class 6 Universal, omni-planar (Fig. 16.7)

Class 1a

These attachments do not allow any movement between abutment teeth and RPD. Most of the intracoronal attachments are in this group. Solid, rigid, non-resilient characteristics of these attach-

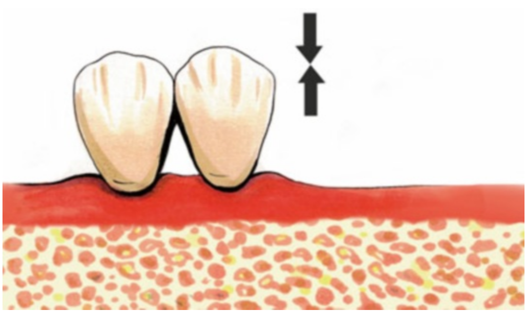

Fig. 16.2 Attachment classification: class 1a or class 1b rigid attachment

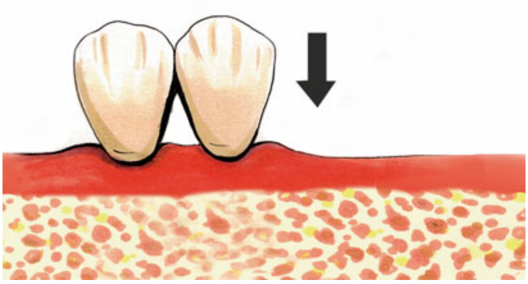

Fig. 16.3 Attachment classification: class 2 vertical resilient

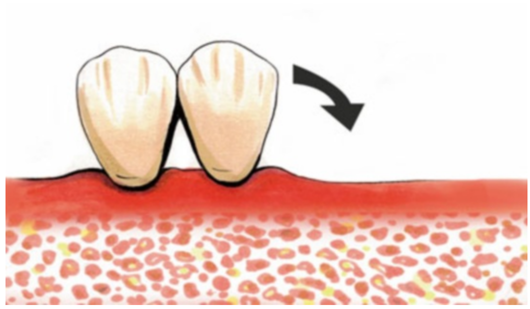

Fig. 16.4 Attachment classification: class 3 hinge resilient

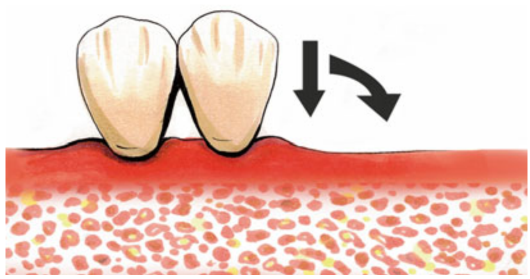

Fig. 16.5 Attachment classification: class 4 vertical and hinge resilient

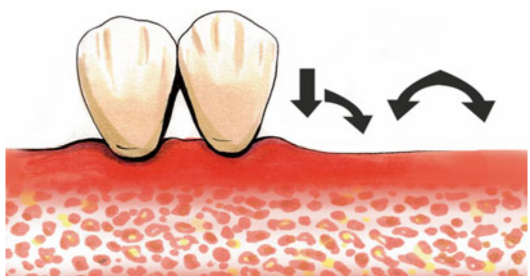

Fig. 16.6 Attachment classification: class 5 rotational and vertical resilient

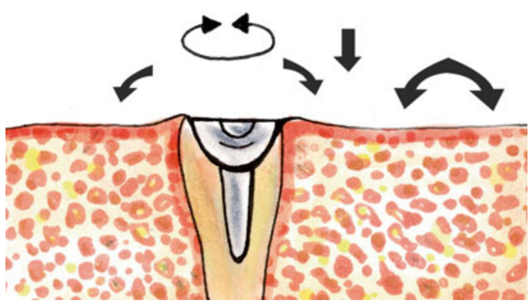

Fig. 16.7 Attachment classification: class 6 universal, omni-planar

ments give them a very limited range of indications like tooth-supported RPDs. Chayes, Crismani and McCollum are the commonly used attachments in this group.

Class 1b
These attachments are very similar to class 1a attachments. The difference of this group is the presence of an additional part that locks the attachment components. They are also solid, rigid and non-resilient and only used in tooth-supported RPDs. Schatzmann and Stern Latch may be regarded as the most preferred class 1b attachments.

Class 2
Class 2-type attachments have only vertical resilience. Only vertical occlusal loads are transferred to alveolar ridge while the RPD is in function. Resilient Dolder and Hader bar attachments are cited in this group when two or more bar units with resilience parts and the metal riders are used.

Class 3
These attachments have hinge resilience and are mostly extracoronal. They allow RPDs to make rotational movements around the fulcrum line. Dalbo, Preci-Vertix and Variosoft are the most favoured class 3 attachments.

Class 4
This group of attachments combine the features of class 2 and class 3 attachments. Under functional loads, they show both hinge movements and vertical resilience. Dalbo S is an example of class 4 attachments.

Class 5
These attachments have a motion capacity in all directions and therefore show all the resilience mechanisms. ASC 52 and Ceka may be presented as examples for this attachment group. Extracoronal class 5 attachments may be precision or semi-precision.

Class 6
Most stud attachments belong to this group. Universal and omni-planar attachments have a motion capacity in all directions; they even allow rotation around their long axis if there is a single abutment used to retain an overdenture.

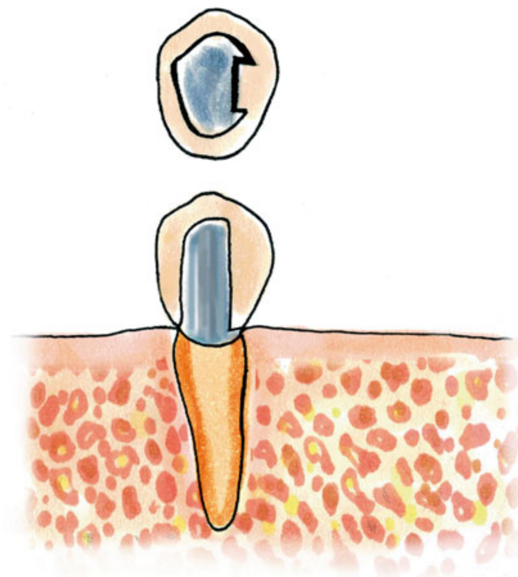

Fig. 16.8 Box-type tooth preparation of abutment teeth for intracoronal attachments

16.2.2 Classification of Attachments According to Their Location on Abutment Teeth

1. Intracoronal attachments (Fig. 16.8)
2. Extracoronal attachments (Fig. 16.9)
3. Stud-type attachments (radicular/irradicular) (Fig. 16.10)
4. Bar-type attachments (Fig. 16.11)

16.2.2.1 Intracoronal Attachments

Generally, intracoronal attachments are non-resilient and provide all functions of direct retainers. The main advantage of intracoronal attachments is the direction of occlusal forces parallel to the long axis of abutment teeth. On the other hand, the necessity of box preparation leads to more reduction of abutment teeth, and their non-resilient nature makes them unfavourable for distal extension RPDs (Fig. 16.8).

Intracoronal attachments consist of two parts: a groove and a flange. Groove is embedded into

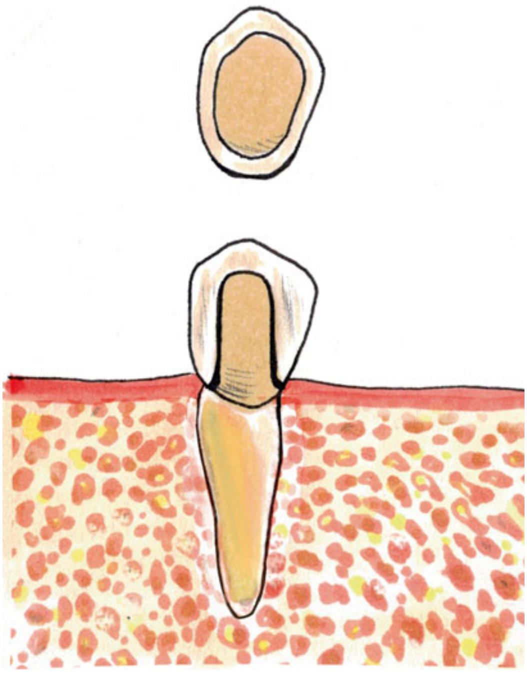

Fig. 16.9 Regular tooth preparation of abutment teeth for extracoronal attachments

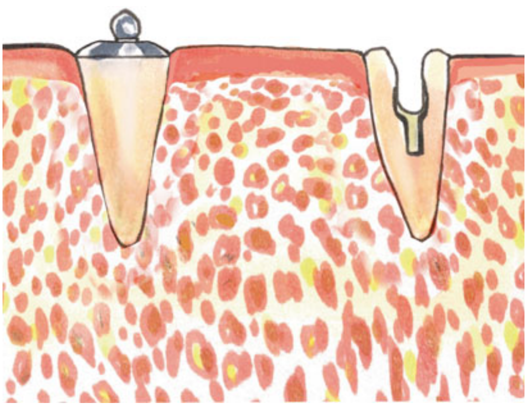

Fig. 16.10 Stud-type attachments (radicular/irradicular)

the crown and flange is merged into the RPD. Herman Chayes designed a T-shaped attachment in 1906 which was the first commercially available intracoronal attachment and is still in the market with a few modifications. His design has particular functions of a clasp like retention and support. Retention mechanism is maintained by the surface contact area between the parts of the attachment. Later, Chayes designed another H-shaped intracoronal attachment in 1912 which has great advantages over earlier T-shaped ones. External flange of H-shaped attachment increases the surface area twice and provides extra strength. Chayes attachment is a class 1a rigid attachment and should only be used with tooth-supported RPDs. Continuous insertion and removal of the RPDs may result in a decrease in the friction-dependent retention of these attachments. A razor blade or a scalpel may be used to adjust the retention by opening the two parts of the attachments. The manufacturers fabricate numerous attachments, and selection of the correct attachment type depends on the shape and size. The Crismani, McCollum and Stern Latch are the commonly used examples of intracoronal rigid attachments. The Crismani intracoronal attachments are available in two different dimensions. The unit is regularly 7 mm long but can be shortened to 2 mm. The Crismani attachment is a class 1a rigid attachment having a dovetail design with a central groove for adjustment and should only be used with tooth-supported RPDs. The McCollum attachment is also a class 1a rigid attachment and again should only be used with tooth-supported RPDs. Stern Latch is an intracoronal rigid precision attachment for non-resilient RPDs. The Stern Latch intracoronal attachments are precisely manufactured to "0.0001" tolerances which correspond to interchangeability of parts. The female part of Stern Latch may either be soldered to crowns or cast with precious and non-precious alloys. The male part of Stern Latch may be soldered or laser welded to RPD framework or cast with gold alloys. For the abutment tooth selection, a minimum of 4 mm vertical and buccolingual length is required. It should be underlined

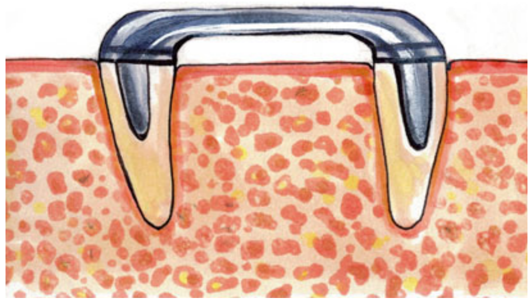

Fig. 16.11 Bar-type attachments

that the patients who will use the RPDs with these attachments should be capable of using this mechanism, and the patients should be warned about this situation before starting the treatment.

The clinician adjusts the attachment chairside to provide the minimum retention necessary to hold the denture in place. Too much retention will cause excessive attachment wear and make the denture difficult to insert and remove. The clinician should try the denture in the mouth, enlarge the retention split slightly and reseat the RPD. If the retention of the RPD is not enough, the procedure should be repeated.

16.2.2.2 Extracoronal Attachments

Resilient and non-resilient types of extracoronal attachments are available in the market. The abutment teeth are prepared with less reduction, and the need for endodontic treatment is reduced with extracoronal attachments when compared to intracoronal alternatives (Fig. 16.9). They also provide an easy path of insertion. Most extracoronal attachments have variable resilience mechanisms. As the extracoronal parts cover extra surface for plaque accumulation, hygiene management may be compromised. It is difficult to clean the attachment parts with a toothbrush, and regular flossing is required. Mouthwash and rinse may also help oral hygiene management. Long extracoronal attachments have mechanical advantages like altered stability and increased retention area. However, plaque accumulation and space requirement for the attachments within the denture base may be regarded as disadvantages. Extracoronal attachments should be placed on the midline of the residual alveolar ridge. However, if this placement provokes aesthetic considerations, they may be placed slightly lingually. Too lingually placed attachments may cause problems like undesirable artificial tooth placement and overcontoured denture bases. Lingual or palatal bracing arm should be prepared for most of the extracoronal attachments in the form of a reciprocal arm and an occlusal rest. If the bracing arm ends with an interlock, attachments become more rigid. Distal extension RPDs require a minimum of two splinted abutment teeth on either side, but if six or fewer anterior teeth are remaining, it is necessary to splint them together to form one rigid abutment. If less than four mandibular anterior teeth are remaining, it is much better to fabricate an overdenture.

Dalbo S

Dalbo S may be regarded as one of the most prevalent class 4 precision extracoronal attachments. The male part is soldered to the abutment crowns, and it comprises an L-shaped bar with a resilient ball joint with vertical translation and rotation. There are two types of Dalbo S attachment system, bilateral and unilateral ones. Unilateral model has an enlarged lateral surface area that provides more resistance to lateral displacing forces. It is not necessary to use a bracing arm with the Dalbo S attachment because the design of the attachment has a reciprocation system embedded in its body. The precise contact between the vertical surface of the male unit and the female part prevents the distal denture base removing from the mucosa, and this provides a perfect indirect retainer mechanism. The female part has an inside spring which provides a 0.4 mm vertical resilience to the prosthesis and a lamellar design, which makes it achievable to adjust the retention force. The buccal/lingual flanges of the lamellar design are slightly bent for adjusting the retention. The main disadvantages of the Dalbo S attachment are the space requirement of the female in the RPD and vertical load transfer away from the long axis of the abutment tooth.

Dalbo Mini

Dalbo mini is a class 3 extracoronal attachment with a simplified female compared to Dalbo S. The female part of the Dalbo mini does not have a spring, which allows vertical resilience. Dalbo mini has all the advantages of Dalbo S with less space requirement for the female having a lamellar design in the RPD.

Preci-Vertix

Preci-Vertix is a class 3 semi-precision extracoronal attachment. Easy fabrication procedures and servicing, aesthetics, compatibility with any dental alloy, cost-effectiveness and excellent patient comfort may be regarded as the advantages of this attachment. The vertical height of the male is 5.9 mm but can be reduced to 3 mm when necessary. In case of buccolingual space restrictions, Preci-Vertix is one of the best attachment solutions. A shoulder for a lingual bracing arm is recommended, and this shoulder may be finished with an interlock which gives more rigidity to the RPD. There are different female elastic clips with three friction levels (yellow normal friction, white reduced friction and red increased friction levels). The castable plastic patterns are placed on the abutment crowns with the aid of a surveyor. The wax pattern is cast with a proper alloy and finished. Yellow female is inserted on the male part, a refractory model is fabricated and the framework is waxed. After the framework is cast and finished, yellow elastic clips are inserted into the places prepared. The elastic clips are subjected to wear in time, but it is very easy to replace it (Figs. 16.12, 16.13, 16.14, 16.15, 16.16, 16.17, 16.18, 16.19, 16.20, 16.21, 16.22 and 16.23).

Fig. 16.12 Patient demands for attachment-retained removable partial denture

Fig. 16.13 Tooth preparation for extracoronal attachments

MK1

MK1 is a solid (rigid) semi-precision class 1b attachment. It is indicated mainly for unilateral distal extension RPDs. It is a frictionless attachment; no wear is expected on the moving parts in time. The modular and simple design of MK1 permits the easy exchange of the parts of the attachment. MK1 has an aperture at the buccal

Fig. 16.14 Provisional crowns are cemented

Fig. 16.15 Metal try-in for metal ceramic crowns with Preci-Vertix extracoronal attachments

Fig. 16.16 Aesthetic try-in for metal ceramic crowns with Preci-Vertix extracoronal attachments

Fig. 16.17 An impression is made using a reversible hydrocolloid impression material with the crowns in place for the RPD framework

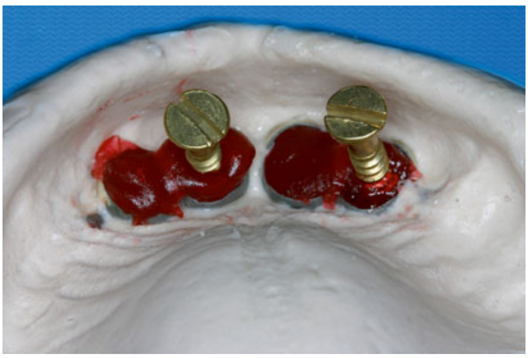

Fig. 16.18 The intaglio surfaces of the crowns are poured using autopolymerising acrylic resin (pattern resin) using retentive dies

Fig. 16.19 Aesthetic try-in is performed taking into consideration the occlusal contacts, centric relation and occlusal vertical dimension

side of the RPD acting as a locking mechanism and a small key to open this lock which is provided by the manufacturer. Splinting the abutment crowns as much as possible is recommended

Fig. 16.20 Occlusal view of aesthetic try-in on plaster model

Fig. 16.21 Occlusal view of cemented metal ceramic crowns with attachments and precisely milled shoulders

Fig. 16.22 Occlusal view of entire maxillary arch with attachment-retained RPD

in order to avoid decementation. Regular controls for the need of relining/rebasing of the RPDs should be checked in order to avoid the possible destructive occlusal forces generated by the rigid behaviour of the attachment. After relining/rebasing, if the RPD does not fit its place easily,

Fig. 16.23 Intra-oral view of attachment-retained RPD

Fig. 16.24 A pure Kennedy class 2 patient with metal plastic old crowns

Fig. 16.25 Try-in of metal framework with a unilateral MK 1 attachment

the interface between the interproximal area of the denture and the abutment crowns should be checked. If there is excess acrylic, it should be ground carefully until the RPD fits the crowns submissively. Bracing arm is also recommended for stability. The difficulties in learning and using the locking mechanism by the patients may be considered as the main disadvantage of the MK1 attachment system. A clinical case of MK 1 is shown in figures (Figs. 16.24, 16.25, 16.26, 16.27, 16.28, 16.29, 16.30 and 16.31).

Ceka

Ceka is a class 5 attachment allowing movement in all directions under functional occlusal loads. Ceka attachment has a male pin attached to the

Fig. 16.26 Occlusal view of entire arch with metal framework

Fig. 16.27 Intra-oral view of metal porcelain crowns with unilateral MK 1 attachment-retained RPD

Fig. 16.28 Lateral view of unilateral MK 1 attachment

RPD and a female part joined to the abutment crowns. As the other attachments, Ceka needs at least 5 mm abutment length. Additionally, sufficient buccolingual space to cover the 4 mm diameter of the ring and allowing an adequate denture base thickness are required. Ceka attachment acts like direct retainer so it should be combined with an occlusal rest and a lingual bracing arm with a shoulder. This arm prevents lateral movements of the RPD and guides it while seating in place. Ceka system includes both resilient and rigid attachment types. Resilient Ceka has a spacer between male and

Fig. 16.29 Unilateral RPD with MK 1 attachment

Fig. 16.30 Lateral view of an FPD and the RPD with MK 1 attachment in situ

Fig. 16.31 The smile of the happy patient

female parts while processing the RPD. The manufacturer produces special equipment for activating and deactivating the male part to adjust the retention force. Additionally, the precision and semi-precision form of the Ceka attachment is available in the market. The

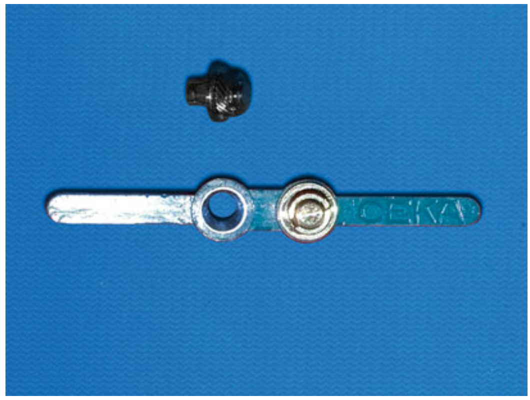

Fig. 16.32 The female part of the attachment has different castable forms with precious or non-precious alloys and a prefabricated form made-up with high fusing alloys. The prefabric model for casting with a non-precious metal is shown

female part of the attachment has different castable forms with precious or non-precious alloys and a prefabricated form made up with high fusing alloys (Fig. 16.32). The female ring should be kept short to reduce the leverage forces applied to abutment tooth. The female ring should be placed as close as possible to mucosa in order to overcome the vertical space requirement, gingival hyperplasia and torque forces acting on the abutments. The retention force should be adjusted with the aid of proper adjustment tools supplied by the manufacturer; otherwise, male-retaining pins may be easily damaged. The retention force of the male pins should be reduced when the denture is delivered for the first time. Relining/rebasing of the RPDs requires care and precision. A specific spacer should be inserted between the male and female parts before making the impression. The pressure for seating the denture, while making the impression for relining/rebasing, should be applied from bracing arms, occlusal rest and over the attachments. An overall impression with an irreversible hydrocolloid should be made for removing the RPD from the mouth. The spacer must be used while processing the relining procedures in laboratory. The spacer will be removed when the denture is seated in place after relining/rebasing.

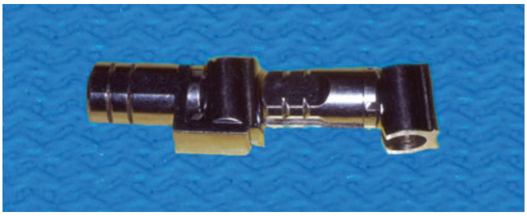

Fig. 16.33 The ASC 52 has two different male parts with protection and without protection

Fig. 16.34 Initial intra-oral status

ASC 52

ASC 52 is also a class 5 attachment allowing movement in all directions under functional occlusal loads. Precision and semi-precision types of ASC 52 are available for different applications. The main advantage of the ASC 52 is the stress-breaking feature that is designed from CARDAN JOINT principle according to the requirements of dentistry, and therefore it is indicated for bilateral distal extension cases with elastic mucosa. The ASC 52 has two different male parts with protection and without protection (Fig. 16.33). The RPD is easily inserted and removed without any risk for the abutment teeth. The removable part of the RPD is attached securely to the abutment tooth without applying any destructive loads. The retention mechanism is based on the special adaptation principle of the ball/socket joint. The female part of the attachment may either be cast or welded to the abutment crowns. The prefabricated male part is embedded in the RPD. The retention force and movement capacity of the RPD is adjusted from the spring located in the male part with a specific screwdriver. The retention spring and the ball can be easily changed if they are worn. A clinical case of ASC 52 is shown in figures (Figs. 16.34, 16.35, 16.36, 16.37, 16.38, 16.39 and 16.42).

Fig. 16.35 Occlusal view of the entire maxillary alveolar ridge

Fig. 16.36 Six or less remaining anterior teeth should be prepared to form one rigid abutment

Fig. 16.37 Temporary crowns are made and cemented

Fig. 16.38 The close-up view of extracoronal part of the metal ceramic crowns

Fig. 16.39 The male part of the ASC 52

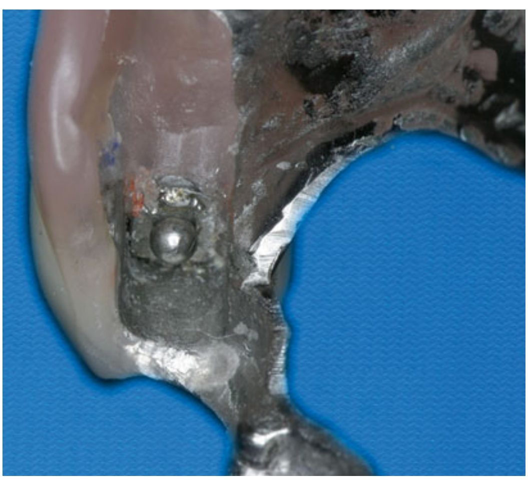

Fig.16.40 ASC 52 is fixed to the RPD with cold-curing acrylic

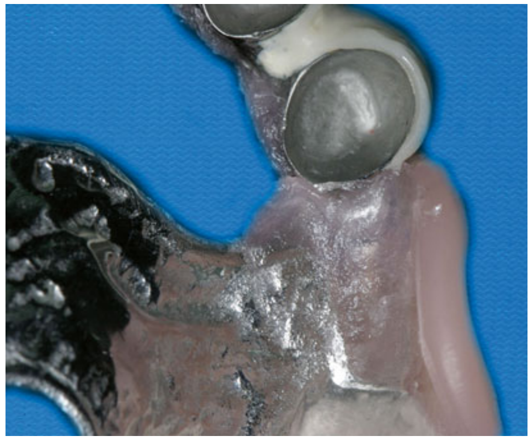

Fig.16.41 The attachment parts are covered with cotton pellets or petroleum jelly in order to avoid cement escape between the attachments and the soft tissues

Fig. 16.42 The view of maximum intercuspation of the RPD

Clinical Procedures of Extracoronal Attachments

1. Abutment teeth are prepared. It has been reported that at least two abutment teeth should be splinted if they will retain an attachment for an RPD. Preservation of tooth structure, retention and resistance form, marginal integrity and conservation of periodontal structures are essential for tooth preparation.
2. Impressions are made with an appropriate elastomeric impression material and sent to the laboratory for the fabrication of cast frameworks. Provisional crowns are prepared and cemented until the next appointment.
3. Try-in of the metal framework of the crowns is performed with marginal integrity; passivity, occlusion and substructure design are inspected. The distance between the gingival

tissues and the bottom part of the extracoronal attachments should be inspected. Attachments should touch the gingival tissues slightly and should not apply pressure, and there should not be a big gap in between in order not to cause a subsequent gingival hyperplasia. Bite registration and retruded contact position are established by using wax or an elastomeric registration material. Colour, hue and shade selection is completed, and the metal frameworks are sent to the laboratory for the application of veneering materials.

4. An aesthetic try-in of the veneering materials is performed. During the try-in, size and tightness of proximal contacts, marginal integrity and occlusion are checked and verified. An impression is made using a reversible hydrocolloid or a polyether impression material with the crowns in place for the RPD framework. The impression is poured with dental stone, but the intaglio surfaces of the crowns are poured using autopolymerising acrylic resin (pattern resin) using retentive dies to provide extra resistance while milling the crowns for refining shoulders acting as occlusal rests.
5. RPD framework is cast and attached to the crowns and tried in the mouth. After the harmony of a major connector with the soft tissues is evaluated, occlusal vertical dimension and retruded contact position are determined, and the framework is sent to the laboratory for artificial tooth setup.
6. Aesthetic try-in is performed taking into consideration the occlusal contacts, centric relation and occlusal vertical dimension.
7. Glazed crowns and finished RPDs are attached together and applied to the mouth. Any misfit of the crowns or the RPDs is inspected. Except the intaglio surface of the crowns, petroleum jelly is applied to every other part of the crown-RPD assembly. Additionally, the attachment parts are covered with cotton pellets in order to avoid cement escape between the attachments and the soft tissues. If the crowns are not cemented with adhesive cements, the excess visible cement is cleaned after setting and a day after appointment is given to the patient instructing not to remove the RPD. One day after, the RPD is removed and excess cement cleaned and the cotton pellets are removed. Occlusal contacts and RPD borders checked using pressure-indicating paste and articulating papers with different thicknesses. RPDs are delivered to the patients after describing the insertion and removal of the prosthesis.

Fig. 16.43 Stud attachments are usually used after root canal treatment in order to use the root for a retaining structure

16.2.2.3 Stud Attachments

Stud attachments are one of the most preferred attachments in prosthodontics and currently mostly used in implant-assisted removable prosthesis. Stud attachments are usually used after root canal treatment in order to use the root for a retaining structure (Fig. 16.43). There are two types of stud attachments: radicular or intraradicular types (Fig. 16.10). The male part is soldered or cast to a root-retained cap, and the female part is embedded in the denture base for the radicular ones. The male part is embedded in the denture base, and the female part is prepared on the abutment teeth for the intraradicular ones. These attachments are either placed directly into the root or soldered/cast to a root-cap coping. The female part of the intraradicular stud attachment is placed within the root shape. Better oral hygiene and reduction of crown-root ratio are the main advantages of stud-type attachments. If the root canal is used for retention, at least 2/3 root length should be used, and the crown height should not exceed 2–3 mm for the accomplishments of ferrule. Inclination of abutment teeth will be managed by a dental technician and the production process with a dental surveyor. If there is a discrepancy of more than 15° between the trajectories of implant abutments, this type of attachment should not be chosen.

Stud attachments tolerate 5–20° of divergence with each other according to their brand. Shorter attachments have better toleration capacity. Taller attachments may need precise attention on the path of insertion. There are different types of stud attachments according to their resilience characteristics. Most of the stud attachments are class 3 hinge resilient attachments, but there are also some class 4 attachment types showing hinge and vertical resilience. Though most of the stud attachments require less space, there may be some patients who do not have sufficient space because of the eruption of teeth. Mounted diagnostic casts are very useful to determine the required space for the stud attachments, and it should be emphasised that the presence of attached gingiva around the abutment teeth provides better prognosis. Usually one stud attachment on each side of the dental arch will be enough, and other remaining roots may be covered with metal caps if they exist. Two adjacent roots with stud attachments will only weaken the acrylic of the RPD and create problems in the future.

Types of Stud Attachments

Preci-Clix

This type of attachment has a wide range of clinical indications from root-supported overdenture to extracoronal attachments. It has a 4 mm long design, which allows the female to engage all the surfaces of the ball. An audible click sound will be heard when the patient inserts the RPD in place. This attachment will tolerate 30° divergence, and females may still engage the undercut of the attachment. The system has a metal housing for the plastic clips and plastic inserts at different retention forces. There are also kits for precision and semi-precision applications. This attachment provides a class 3 hinge resilience.

Swiss Dalbo System

Swiss Dalbo System is in use for over 40 years. Highly resistant compact shape and precious lamellar design of the female make the Dalbo System reliable and durable. The Swiss Dalbo System is easy to use and requires minimum space in denture, and the retention force is adjusted according to patients' expectations. There is a clear nylon silicone sleeve around the female that protects the lamellae from becoming blocked by acrylic in laboratory or intra-oral practice. Metal lamella insert is screwed inside the housing for adjusting retention force. This attachment system tolerates 40° divergence, and the precious lamellae may be changed when needed. This attachment has a class 3 hinge resilience. Swiss Dalbo System recommends two different metal females with round and elliptic shapes. Overall height of the attachment differs from 2.9 to 3.7 mms.

Gerber Unit

The Gerber Unit was originally designed by Prof. A. Gerber and is available in two sizes. The Gerber Unit is normally a rigid stud attachment that has a slight vertical resilience. The system consists of five parts, and the main advantage of the Gerber Unit is the interchangeability of the parts. The interchangeability, replicability and adjustability of the system make it reliable. On the other hand, requirement of special accessory tools, mandrels and the cost of the system are the main disadvantages of the Gerber Unit. Overall height of the Gerber Unit differs from 3.7 to 5.2 mm. Prof. Gerber pointed out that two attachments are sufficient to retain a denture; three or more abutments are unnecessary. A simple coping should be made for the excess roots. If two adjacent teeth are used, a resilient-type attachment should be chosen for the posterior tooth and the rigid for anterior because of the altered displacement of the denture over the posterior teeth while chewing.

16.2.2.4 Bar Attachments

Bar attachments have been used for nearly 100 years in dentistry. General advantages of the bar attachments are favourable retention, increased stability, reduced crown-root ratio and splinting of the remaining abutments as well as correcting their divergence. On the other hand, vertical and sagittal space requirements show aesthetic and technical problems. Plaque accumulations, mucosal hypertrophy, requirement of technical skills with clinical expertise, complexity of the relining/rebasing and repair procedures are the main disadvantages of bar attachments. Bar attachments are used to join roots, teeth, crowns and implants. Bar attachments are cast with hard precious, semiprecious or non-precious alloys or may be prefabricated gold. Some bar types such as Dolder bars may be soldered to root caps or crowns. Most abutment teeth need root canal treatment, and placing dowels in root canal can give extra retention to bar attachment. Plastic and metal clips are both available for different types of bar attachments.

Bar attachments are divided into two groups: resilient bars (bar joints) and rigid bars (bar units). Resilient bars (bar joints) provide class 2 (vertical) and/or class 3 (hinge) resilience according to the number of abutment teeth used in the prosthetic restoration. Bar attachments are constructed on at least two abutments. Periodontally compromised teeth require root canal treatments and crown shortening for better prognosis. There are different types of bar profiles such as round, pear shaped and parallel sided "U" shaped.

There is also another classification of bar joints:

- Single-sleeve bar joints
- Multi-sleeve bar joints

Dolder bar is a very good example of single-sleeve bar joints. However, this type of bar joint has to be made straight which may be regarded as a disadvantage. The roots or teeth have to be in a straight line, and a bar may be located lingually to gain more space for the arrangement of the artificial teeth.

There is no need for the bar to run straight when multi-sleeve bar joints have chosen and can follow ridge curvature. On the other hand, the bar with a big curvature may cause excessive load to abutment teeth or roots and may cause periodontal problems. When multi-sleeve bar joints are chosen, the bar must be cast with a rigid alloy.

Metal or plastic clips are available for single- or multi-sleeve applications.

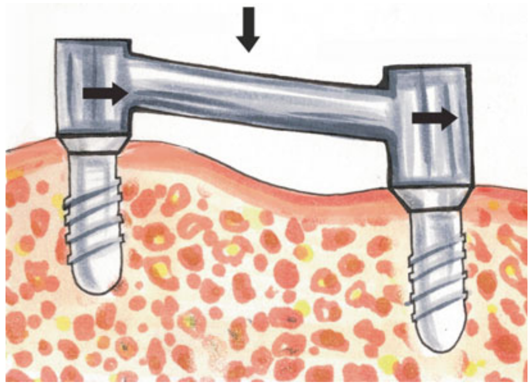

Fig. 16.44 If the levels of abutment teeth are not aligned at frontal plane, bar should be placed parallel to the hinge axis

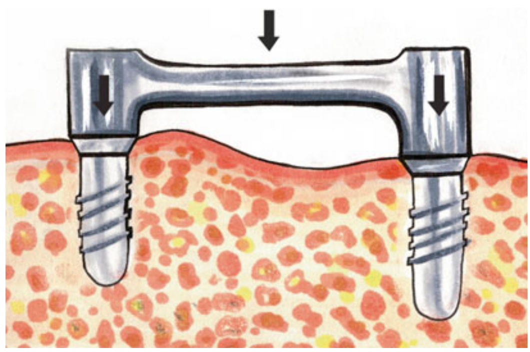

Fig. 16.45 The arrangement of the levels of the implants provides balanced load transfer

Fundamentals of Bar Designs

As a general rule, if the levels of abutment teeth are not aligned at frontal plane, the bar should be placed parallel to the hinge axis (Figs. 16.44 and 16.45). There should be at least 2 mm or more gap between the bottom of the bar and mucosa. This space allows easy cleaning of the food particles by saliva or cleaning tools. If the space is narrow, this will cause plaque and calculus accumulation, and oral hygiene management will be problematic. If the bar slightly compresses the mucosa, this will cause hyperplasia of the gum. The bar should be placed directly above the alveolar ridge. If the bar is positioned lingually, it may restrict the tongue space. If the bar is located buccally, this may disturb the lips. These scenarios complicate the fabrication of dentures. Bars should follow a straight line between the abutments. In case the curvature of the alveolar crest does not allow a straight design, the prognosis of the abutment teeth may become unclear.

If there are two abutment teeth connected with a bar attachment, borders of the denture should be like a conventional complete denture. But in the presence of four or more abutment teeth, flanges of the denture may be shortened. If the distance between the abutment teeth is long, the resilient bar should be used. Rigid alloys should be used to construct multi-sleeve bars, which follow the curvature of the alveolar crest.

Rigid bars are also used as auxiliary components to extracoronal attachments. Two canines of a Kennedy Class I Mod 1 case is a typical example to the concept. The canines are not reduced to gingival level to serve under an overdenture; instead they are kept as abutment teeth, restored with single crown restorations, for an RPD. A rigid bar is used to splint the two canines. The bar provides indirect retention to the RPD as the axis of rotation is moved posteriorly with the help of distal extension extracoronal attachments; however, it does not contribute to direct retention actively. This design offers a support polygon out of two teeth with posteriorly extended support points. The distal extensions establish a lever arm that exerts torque forces on the splinted abutment teeth when the saddles make dislodging movements. To minimise any harmful effects, distal attachments should be chosen among resilient types. In many aspects, the advantages of this design over other alternatives, like an overdenture, are quite questionable, but occasionally, it may be preferred for selected cases.

Metal and plastic sleeves will be available, and the advantages of metal sleeve are that it has more wear resistance, retention force can be adjustable and total bar dimensions can be smaller; on the other hand, replacing a metal clip is more difficult and needs more chairside effort. The advantages of plastic clips are as follows: they are easy to change, clips with different retention forces are available, they need less time at chairside but need more space, they do not allow adjustment, and they can be worn easily.

Hader Bar

Helmut Hader, a master technician, developed a semi-precision attachment bar system in 1973. The Hader bar and rider system is one of the most popular bar systems due to its cost-effectiveness and simplicity. This system allows hinge movement when a single Hader bar is used with plastic female rider and has a mechanical snap retention mechanism. The Hader bar system is a semi-precision bar system with a castable bar replica. The Hader bar is available in two sizes: standard (8 mm height) and short (4.5 mm height). The Hader bar will be shortened up to 2.5 mm. A common application is processing the Hader Metal Housings into the denture utilising the Hader Processing Spacers and then using one of the four plastic female riders in the metal housings. The system has four different colour-coded female riders with different retentive strengths: yellow standard, white decreased, red increased and a new blue rider for worn bars. Using metal housing for female riders is highly recommended in clinical usage for easy maintenance. The Hader bar and plastic rider normally allow only rotational movement when two abutment teeth are used. The Ackerman gold and stainless steel clips with vestibular-lingual retentions and with mesial-distal retention are also available with spacer, which will allow vertical resilience to dentures.

Dolder Bar

Dr. Eugene Dolder in Switzerland developed this bar system. The main point of the Dolder bar design is to allow remarkable amount of both vertical and rotational movements around the long axis of the bar. The Dolder bar works best where the remaining teeth or roots are in a square arch and can be joined by a straight line. Patients with adequate inter-alveolar distance and when a maximum retention is expected are the main indications. On the other hand, patients with poor oral hygiene and decreased manual dexterity are the main contraindications. Dolder bar system is originally based on wrought wire pear-shaped precious metal bar and metal precious rider. Plastic replicas for waxing up between natural abutments and implant plastic cylinders are also available for non-precious bar system. Dolder bars have either pear-shaped or U-shaped cross sections and are available in two sizes: standard (diameter 2.2 mm, height 3 mm) and mini (diameter 1.6 mm, height 2.3 mm). The pear shape is used for a resilient prosthesis and called bar joint. The U shape is for a rigid or non-resilient prosthesis and called bar unit. Resilient pear-shaped bars are normally ideal for tooth (implant)- and mucosa-supported dentures. Pear-shaped bar and rider will provide vertical and rotational resilience. There is a spacer between the bar and rider, which will be removed after the acrylic resin and has been polymerised. The spacer will allow the denture vertical and rotational freedom over the pear-shaped bar. The retention force of the metal rider will be fully adjusted according to the patient's expectations. The Dolder bar system does not offer plastic riders.

Ackermann Bar

Dr. Ackermann's bar is similar to Dolder bar with different cross sections and a semi-precision bar system which is cast by gold. This is also a multi-sleeve bar system, which can follow the ridge contour. Oval and round cross-sectioned bars are available with metal riders and a spacer. Round bars are the most versatile and can be set in all planes. The riders of the Ackermann bar have retention parts placed in acrylic resin that lie buccolingually. This rider requires more space so be careful when removing the rider for rebazing. When using Ackermann bar unit, it is recommended that 5 mm extension from the most distal root will be made for extra retention.

Clinical Procedures of Bar Attachments

1. Abutment teeth are prepared. If necessary, crown height is adjusted to 2 mm. The final impression is made with polyvinylsiloxane or polyether impression material. The impression is poured with dental stone, and record bases with occlusal rims are prepared.
2. The vertical dimension of occlusion and retruded contact position are determined with the guidelines described in Chapter 13.
3. After the aesthetic try-in appointment, a silicone index is prepared to check if there is adequate space for the bar and the rider and additionally to decide their position.
4. The bar is fabricated with an appropriate alloy, and an individual tray is also prepared.
5. The passive fit and the accuracy of the bar on the abutment teeth are checked. If the bar does not fit to the abutments passively, it is cut with an appropriate bur between the abutments and joined together with an autopolymerising acrylic resin (pattern resin), and the passivity is checked again in the mouth and a new impression is made and the cut bar parts are welded in the laboratory. The cast is resent to the laboratory and veneering materials applied to the crowns. A functional impression is made with the prepared individual tray by using zinc oxide eugenol or polyether impression materials with the bar in place.
6. Another aesthetic try-in is performed with the bar in place. After the vertical dimension of occlusion and retruded contact position are verified, the RPD is processed using conventional laboratory methods.
7. The bar and the RPD assembly are seated on the abutment teeth to check the retruded contact position and occlusal contacts before cementation. Petroleum jelly is applied to the bar except the intaglio surface of the crowns and the bar seated on the RPD. Cementation procedures are performed afterwards. If adhesive cement is not used, the RPD is removed the day after.

16.3 Double Crown Systems

The terminology used in the description of double crowns is unclear. In 1886, R. Walter Starr first described telescopic crowns which have proven

Fig. 16.46 A telescopic crown precisely represents a double crown that achieves retention by friction of parallel-sided surfaces

an effective means of retaining RPDs. The similarity of double crowns to a collapsible optical telescope urged him to define the system as the "telescope system." All double crown systems are called telescopic crowns, but a telescopic crown precisely represents a double crown that achieves retention by friction of parallel-sided surfaces (Fig. 16.46). Double crown systems transfer forces along the direction of the long axis of the abutment teeth thereby protecting them from the dislodging movements of the RPDs and provide support and guidance which is worthy for patients having neuromuscular coordination problems. Thin metal primary crowns do not intrude the periodontal tissues, and oral hygiene is provided easily by removing the RPD. Loss of retention is one of the most common technical failures and independent from the friction fit concept which is used to retain the denture. A common disadvantage of all double crown systems is the need for more extensive tooth reduction to provide enough space for the primary and secondary crowns, which may cause a requirement of root canal treatment, especially in younger patients.

The properties of the alloy chosen for double crowns are very important. The elastic modulus of a Co-Cr-Mo alloy is about twice as high as the elastic modulus of a type IV alloy with a high gold content. Therefore, if a high gold content alloy is used, appropriate major and minor connectors delivering the rigidity of the RPD should be planned. Base metal alloys provide enough rigidity to fabricate a framework without major connectors. The outer crowns are able to serve as minor connectors between the bases. The fabrication of cast double crown-retained RPDs is a technique-sensitive process and requires a qualified laboratory. Today, primary crowns may also be manufactured with zirconia or laser-sintered base metals, and the secondary crowns or the retentive part may be manufactured by electroforming afterwards (Figs. 16.47, 16.48, 16.49, 16.50 and 16.51). Easy establishment of higher retention forces may be regarded as the advantage of the electroformed secondary crowns, whereas high costs and requirement of extra equipment as the disadvantages compared to conventional methods. The framework of an RPD with a double crown system can be constructed in two methods: with a conventional major connector (Fig. 16.52) and a bridge-like framework without a major connector (Fig. 16.50). Bridge-like frameworks should not be preferred if there is insufficient number of abutment teeth, if there is a significant loss of soft tissues that should

Fig. 16.47 Telescopic prosthodontic treatment of a patient with hemimandibular elongation

Fig. 16.48 Telescopic primary crowns are made with base alloy, and root caps are made by using an electroforming technique

Fig. 16.49 Secondary crowns are made by using an electroforming technique

Fig. 16.50 Bridge-like framework without a major connector

be restored with a removable appliance or if the location of the remaining teeth is not suitable.

Framework with a conventional major connector is indicated in the following situations:

- Replacement of bilateral posterior and anterior missing teeth with supporting weakened abutments
- Bilateral splinting of the posterior missing teeth supported by one telescopic crown from each side
- Absence of unilateral abutment teeth
- Several abutment teeth with unclear periodontal prognosis

Bridge-like framework without a major connector is indicated in the following situations:

- Numerous periodontally healthy abutment teeth can enable the reduction of unnecessary bulk of the denture.

Fig. 16.51 Aesthetic, functional and hygienic RPD in situ

Fig. 16.52 Framework with a conventional major connector

- Abutment teeth with sufficient crown heights.
- A unilateral edentulous area with natural teeth both anterior and posterior to the area.

There are three different double crown systems for retaining RPDs:

1. Telescopic crowns having parallel milled surfaces that achieve retention by frictional forces.
2. Conical or conus crowns exhibiting friction only when completely seated using a "wedging effect."
3. The double crowns with clearance fit accomplishing no friction or wedging during insertion or removal. Retention is generated by using additional attachments.

16.3.1 Telescopic Crowns

Telescopic crowns have been used for more than hundred years in dentistry. Telescopic crowns have parallel milled surfaces which achieve retention by frictional forces. The system consists of one inner (primary) and one outer (secondary) crown. Primary crown should have at least 4 mm vertical height, and it is cemented to prepared abutment teeth, and secondary crown is soldered to the RPD framework (Fig. 16.53). The retention force is activated when the secondary crown contacts the primary crown and continues until the RPD is inserted. Noble alloys (Fig. 16.54) are the first choice when manufacturing telescopic crowns, but nowadays due to economic reasons, base alloys (Fig. 16.55) are also used. Abutment teeth may require root canal treatment in order to avoid overcontoured restorations. Cross-arch stabilisation, improved oral hygiene, less wear compared to other attachments, reasonable retention force and aesthetic appearance are the main advantages of the telescopic crowns (Fig. 16.56a–c). Cross-arch stabilisation of periodontally involved teeth can alter the prognosis of abutment teeth. If an abutment tooth is lost, secondary crowns are converted to pontics by filling the gaps with acrylic. The retention force decreases but remains acceptable as the abutment teeth are lost until one tooth is left. Abutment teeth, which are not used for retention purposes, are also used for stabilisation and support. Telescopic crown-retained RPDs have rigid and resilient types. The difference of the two systems is that the resilient telescopic crowns have a very small gap between the occlusal surfaces of the primary and secondary crowns, and this gap allows movements of the denture towards the oral mucosa by the functional occlusal forces to provide maximum soft tissue support. Advantages and disadvantages of telescopic crown-retained RPDs are listed in Table 16.1

Fig. 16.53 Secondary crown is soldered to the RPD framework

Fig. 16.54 Noble alloys are the first choice when manufacturing telescopic crowns

Fig. 16.55 Base alloys can be used due to economic reasons

16.3.2 Conical Crowns

Conical crowns or conus crowns were first described by Körber in 1958 and exhibit friction only when the RPD is completely seated using a "wedging effect." The magnitude of the wedging effect is mainly determined by the convergence angle of the inner (primary) crown. This convergence angle can be adjusted from 4° to 8° to afford the adequate retention force to retain an RPD. When the convergence angle becomes smaller, retentive force becomes high. The taper

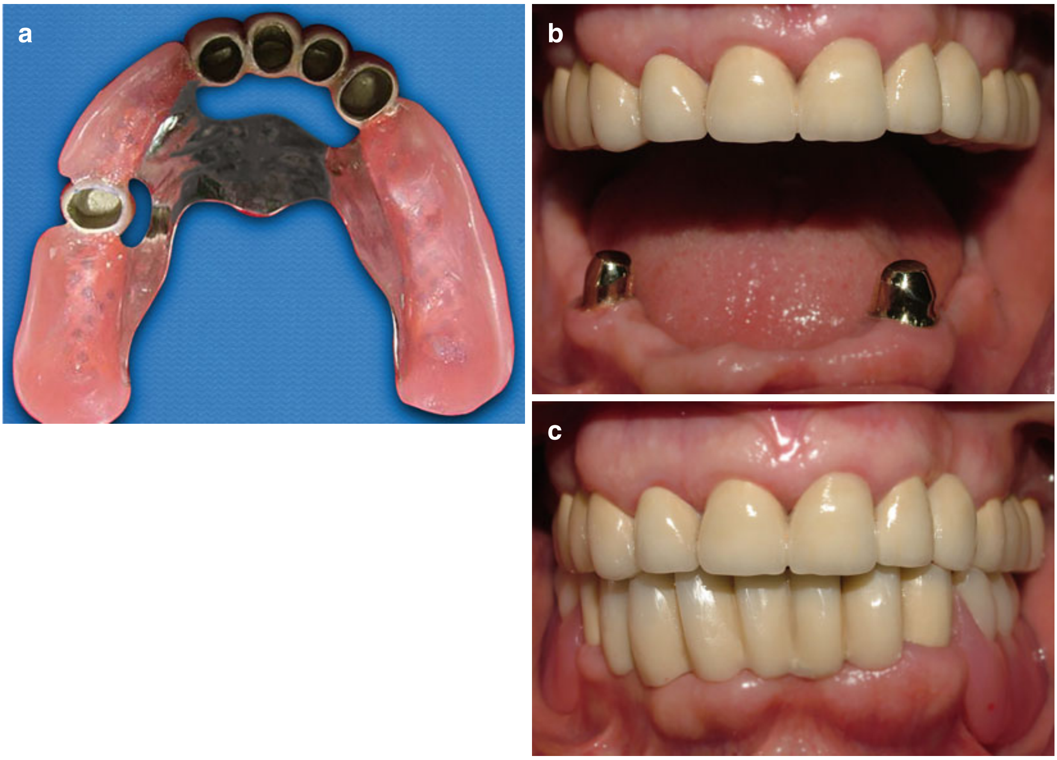

Fig. 16.56 The main advantages of telescopic crowns are (**a**) the cross-arch stabilisation of the abutment teeth, (**b**) improved oral hygiene and (**c**) aesthetic appearance

Table 16.1 Advantages and disadvantages of telescopic crown-retained RPDs when compared to conventional RPDs

Advantages	Disadvantages
Adjustable retention force	High frictional forces acting on abutment teeth while removing the RPD
Long-term retention force stability	Requirement of increased vertical and buccolingual space
Splinting effect of abutment teeth	Requirement of root canal treatments when necessary
Good periodontal health	Wear easily
Good aesthetic results	Metal maybe exposed in cervical region
Retention of the RPD is acceptable until one abutment tooth remains	

angle of the inner (primary) crown depends on the clinical crown height and the periodontal mobility. The number and location of the abutment teeth are the other factors affecting the taper angle, and the total retention force is calculated according to this number. Conus crown-retained RPDs provide all the requirements such as restoration of phonetic functions, arrangement of occlusal stability, preservation of the residual alveolar ridge, stabilisation of temporomandibular joint, and good aesthetics as well as continuous retention and splinting effect on abutment teeth. Conus crown-retained RPDs are rigid and provide respectable support maintaining periodontal health. Advantages and disadvantages of conus crown-retained RPDs are listed in Table 16.2.

Abutment teeth with periodontal problems and compromised soft tissues are the contraindications of conus crown-retained RPDs because of their rigid behaviour. When the retention of the RPD is lost because of the wear of conus crowns, grinding from the occlusal surfaces of primary crowns with a silicone polishing disc may increase the wedging effect and improve the retention.

Table 16.2 Advantages and disadvantages of conus crown-retained RPDs when compared to conventional RPDs

Advantages	Disadvantages
Adjustable retention force	Double crowns sometimes generate overcontoured teeth
Long-term retention force stability	Metal maybe exposed in cervical region
Splinting effect of abutment teeth	Requirement of root canal treatments when necessary
Good periodontal health	When an abutment tooth is lost, the retention of the RPD is compromised
Good aesthetic results	Rigid connection

16.3.3 Double Crowns with Clearance Fit (Marburg Double Crown System)

Clearance fit double crown system, which is also called Marburg double crown system (MDC system), was first described by Lehmann and Gente in 1988. The double crown with clearance fit exhibits no friction or wedging during insertion or removal of the prosthesis. Retention is achieved by using additional attachments. This system may be used to retain both tooth-supported and distal-end RPDs. The secondary crown fits onto the primary crown without any friction or wedging. This clearance fit is precise, allowing a minimal, invisible lateral movement and a smooth, effortless gliding along the axis of the path of insertion. Inner crown is fabricated with a groove for the production of resilience. A 0.3–0.5 mm tinfoil is inserted between primary and secondary crowns before the RPD is processed. After the laboratory procedures, tinfoil is removed and the denture base contacts the denture-bearing mucosa, while there is an additional space between the inner and outer crowns. When an occlusal load is applied, the RPD moves vertically through the mucosa, depending on the resilience of the denture-bearing mucosa, and returns to its former position after the load is removed. A rigid metal framework, including the secondary crowns, is provided by the MDC system. Retention is achieved by using the TC-SNAP system which is an auxiliary attachment. To avoid unfavourable leverage and overloading of the periodontal tissues, the abutment teeth must be shortened until achieving balanced crown-root ratio. This equalisation of crown-root ratio may require root canal treatment followed by post and core restorations. Using a single alloy for the fabrication of primary, secondary crowns and the framework of the RPD provides enough rigidity and decreased manufacturing cost.

Fig. 16.57 Primary crowns with proper retentive elements for functional impression

16.3.3.1 Clinical Procedures of Double Crown Systems

1. Abutment teeth are prepared with a chamfer margin and minimum taper angle. Reduction from the occlusal and buccal surface should be done carefully to prepare enough space for metal and aesthetic materials.
2. Impressions are made using elastomeric impression materials, and a dental stone cast with dies is fabricated.
3. Primary crowns are cast with appropriate alloy, and an individual tray is fabricated with autopolymerising acrylic resin over the crowns. If the interocclusal distance is insufficient, the occlusal vertical dimension should be established before the production of primary crowns, and therefore occlusal scheme of the secondary crown can be made with metal.
4. Primary crowns are tried in the mouth (Fig. 16.57). If the primary crowns are cast without retentive elements, they are attached together with autopolymerising acrylic resin (pattern resin) before the functional impression (Fig. 16.58).

Fig. 16.58 Primary crowns without retentive elements should be attached together with autopolymerising acrylic resin (pattern resin) before the functional impression

Fig. 16.59 Occlusal vertical dimension is established with primary and secondary crowns attached to framework of the RPD

5. The functional impression is made by polyether or polyvinylsiloxane impression materials having hydrophilic properties by using the individual tray.
6. The dies of primary crowns are poured with autopolymerising acrylic resin (pattern resin) using retentive pins. This procedure should be done for milling the primary crowns for the path of insertion and adjusting the retention force.
7. After milling and polishing the primary crowns, secondary crowns and major connectors are fabricated. The passive fit of the primary and secondary crown assemblies are checked in the mouth. Occlusal vertical dimension is established (Fig. 16.59).

Fig. 16.60 RPD is removed preferably next day to avoid the risk of decementation

8. Try-in of the RPD with double crowns is performed checking and ensuring accurate aesthetics and phonetics of the patient.
9. The RPD is processed, finished and polished.
10. Petroleum jelly is applied around the primary crowns and major connectors. Primary crowns are seated into the secondary crowns on the RPD and cemented with zinc polycarboxylate or adhesive cement. During cementation, the RPD should be settled in place completely.
11. After setting of the cement, excess cement is cleaned using appropriate instruments. The RPD is removed preferably next day to avoid the risk of decementation of the primary crowns if the primary crowns are not cemented with adhesive cements (Fig. 16.60).
12. The day after, the RPD is removed and excess cement is cleaned. Occlusal contacts are arranged. Maintenance and cleaning procedures are described to patient in detail and the RPDs are delivered to the patients.

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17 The Role of the Dental Implant in Removable Partial Dentures

Hakan Bilhan

Dental implants, as a helpful adjunct of prosthodontics, may have a key role in partial denture retention as well as stability and support. Not only being a step back solution after loss of several implants, having been placed for a fixed solution, but also as a less invasive method providing a very comfortable remedy, especially for patients with impaired systemic condition hindering greater surgical interventions. A variety of different attachments or abutments can be used ranging from single standing to splinted or resilient to rigid. The position of the implant to be placed depends on the relevant indication. The main aim is to reduce the length of the edentulous space, move the fulcrum more distally, and if possible eliminate a clasp via a suitably positioned dental implant. Implants may additionally offer the advantage of not requiring the use of the teeth as prosthetic abutments, thus playing a protective role on the remaining natural dentition. It may also be speculated that strategically situated implants may help preserving the residual bone especially around the implants. The indications/contraindications, advantages/disadvantages, and clinical approach related to implant-assisted removable partial dentures are presented in this chapter.

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17.1 Dental Implants and Removable Partial Dentures

Several factors associated with removable prostheses, such as impaired function and uncomfortable use, force the majority of patients to prefer fixed prosthetic solutions. Most of the time, undeservedly, factors such as esthetics, higher risk of periodontal disease, alveolar crest resorption, and development of decays on abutment teeth are asserted as an excuse to quit wearing removable dentures. On the other hand, loss of teeth, especially in the posterior, has to be somehow compensated by a prosthetic restoration, since symptoms such as reduced masticatory efficiency, loss of vertical dimension of occlusion, and attrition of anterior teeth may accompany partial edentulism. Clinical studies have shown that partially edentulous patients complained mostly about dissatisfaction, discomfort, occlusal instability, chewing difficulty, and temporomandibular joint (TMJ) disorders. Nevertheless, it is clear that dentures with less mobility will give a better comfort feeling and thus be better accepted.

The implant-assisted removable partial denture (IARPD) represents a cost-effective prosthetic solution for patients with partial edentulism not being immediate candidates for extensive, fixed, and implant-supported restorations. Including dental implants for improvement of removable partial denture (RPD) support and retention as

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well as to enhance patient satisfaction should be considered when planning the treatment with RPDs.

Although not a routine treatment modality, a few strategically placed dental implants combined with the remaining dentition can help to achieve a more favorable RPD design. In cases where fixed rehabilitation is not possible, a few dental implants placed in strategically important positions could help prevent the movement around a fulcrum axis and bring biomechanic advantages by providing vertical support as well. Rotation around the fulcrum axis created between the abutment teeth closest to the edentulous area, namely, the distal abutments against tissues as well as away from tissues, may be prevented by a properly positioned implant.

In mandibular bilateral distal extension RPD situations opposing a maxillary complete denture in some patients, overgrowth of the maxillary tuberosities, papillary hyperplasia in the hard palate, resorption of the anterior part of the maxilla causing a flabby ridge, extrusion of the mandibular anterior teeth, resorption under the RPD bases, and marked tipping of the occlusal plane may appear from time to time. Although the relation between the above-mentioned symptoms and distal extension RPD is still controversial, it may be suggested that the proper placement of one or more implants in combination with the RPD may overcome some of the possible problems. However, a destabilization of the occlusion may occur due to the resorption of the residual ridge below distal extension saddles, as well as with wear of the denture. The placement of an implant beneath a distal extension denture base could be a way to slow down the bone resorption and maintain ridge height. By the elimination of clasps, the esthetic expectations of patients can be satisfied, while reduced displacement of the dentures has ended up in better tissue tolerability and options for RPD use have increased.

As in individual teeth, being evaluated for best use in RPD design to control prosthesis movement, use of an implant should be directed in a similar manner toward the most beneficial movement control. Implant use subsumes all three desired principles demonstrated by prostheses, namely, support, stability, and retention. The major functional demand on RPDs is chewing; thus, the greatest benefit of implant use could be considered as the improved support and stability of the prosthesis. Additionally, the use of implants as a rest by taking advantage of their vertical stiffness characteristic will mostly eliminate compression of supporting soft tissues, control vertical movement of the denture base, and additionally alter fulcrum lines (Figs. 17.1, 17.2a, b, and 17.3). Implants may be considered useful for retentive needs as well, and as mentioned above, implants can effectively alter rotation around a fulcrum line, eliminating it if applied to the most distal end of a denture base. In a more mesial position, it is to be expected to reduce the effects by decreasing the effective lever arm. A very recent numerical study showed that when compared with complete dental arch restoration, RPDs supported by a single implant unit demonstrated decreased stress values and mucosa displacements under vertical and oblique loading conditions. The first report

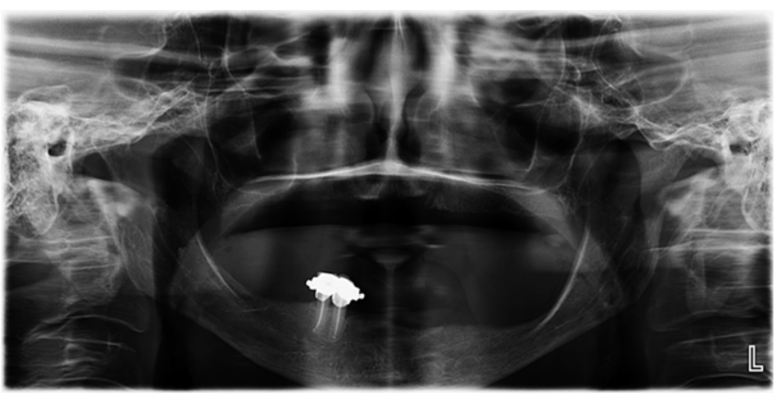

Fig. 17.1 Kennedy Class I situation with a very unfavorable fulcrum

about an implant in combination with a conventional removable partial denture (CRPD) is from 1974, where the authors treated a bilateral distal extension situation with an endosseous blade implant, while the other side of the partially edentulous mandible was used as a control. The follow-up was only 7 months, but improved patient satisfaction had been presented.

One of the greatest advantages of implant use in conjunction with RPDs is that their position can be determined by the clinician in order to find the best suitable location for an abutment. While making decision for the strategic implant position, anatomic characteristics of bone availability should be considered, too, since it would not be a great advantage to a patient if extensive augmentation procedures were required to allow implant placement in conjunction with an RPD. If anatomic needs are met, placement of an implant within the edentulous gap requires consideration of most mesial, mid, or most distal placement.

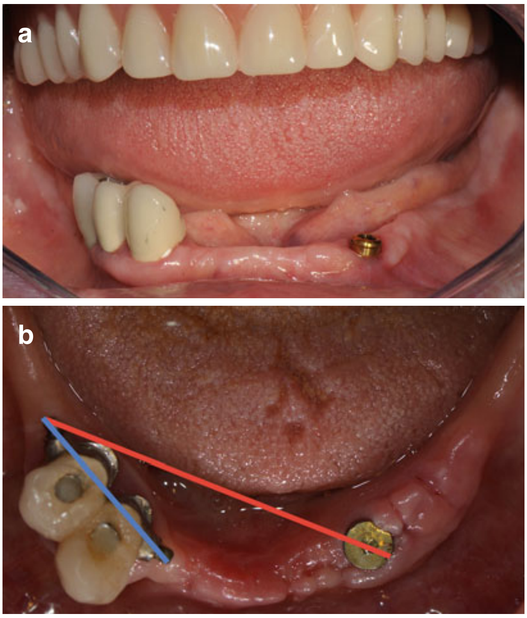

Fig. 17.2 (**a**) A strategically positioned implant for the improvement of the fulcrum position. (**b**) Occlusal view of the altered fulcrum line

Fig. 17.3 The strategic implant attachment in the denture

In distal extension spaces, where no support of the teeth at each end can be expected, only two options may be considered primarily: the CRPD and the fixed/removable implant-supported prosthesis.

Solutions such as the cantilevered bridge or the shortened dental arch (SDA) can be regarded, in case of patient related medical factors, concerns for the risk of surgical morbidity, increased time required for treatment, and costs, hindering the selection of implant therapy, as a compromise.

Today, the SDA concept is widely accepted and practiced by prosthodontists and needs to be considered in the treatment planning of partially edentulous patients as an option (see Chap. 5). This approach provides an affordable treatment method that may provide an acceptable result, improving both oral hygiene and patient satisfaction. On the other hand, there are a minimum number of teeth needed to satisfy patients' functional demands and achieve SDA. Obviously, existing incisors alone will not be sufficient to fulfill the requirements of an SDA. When compared with CRPDs, the SDA showed a long-term comfort and oral function. Nevertheless, it should be pointed out that long-term randomized controlled studies are needed to compare IARPDs with the SDA situation.

The cantilevered solution is without a doubt an option giving a patient a comfortable solution in the beginning. In a case where molars are missing, the clinician can provide a fixed prosthetic alternative with a chewing surface reaching the molar area, without an implant. Here again, the principle of prevention must be respected. The cantilevered option using the teeth neighboring the edentulous area is a risky alternative and not preferred by the author of this chapter.

Damage varying from secondary caries to overloading can lead to loss of the related teeth. A recent evidence-based review article evaluating the long-term success of cantilever cases reported that estimated survival and success rates of cantilever fixed partial dentures (FPD) were lower than previously reported rates for typical end-abutment supported FPDs.

There are several classification systems of partially edentulous situations having been proposed and still in use as mentioned in an earlier chapter. It has been estimated that there are over 65,000 possible combinations of the teeth and edentulous gaps in opposing arches. The most familiar classification originally proposed by Kennedy is probably the most widely accepted system for categorizing of partially edentulous arches today.

The most commonly encountered patient complaints related to RPDs especially in Kennedy Class I (bilateral free end) and II (unilateral free end) cases are missing stability, minimal retention, discomfort upon loading, and esthetic problems caused by clasps and reciprocal arms. Obviously, the Kennedy Class IV in extremely long anterior edentulous spans creates a challenge for the prosthodontist, too. A limited number of implants can help prevent visible retentive elements.

The choice of IARPD treatment is often a useful escape from multiple surgeries or extensive and complicated surgical procedures such as sinus lifting. The demand for prosthodontic treatment is influenced more by esthetic expectations in most industrialized countries. In this manner, a very helpful treatment alternative is the placement of a few interforaminal implants (Fig. 17.4) supporting an anterior fixed bridge with extra coronal precision attachments (Fig. 17.5) and an RPD, thus reducing implant costs as well as the need for extensive surgery. This treatment modality brings the advantage that an edentulous patient feels confident even when the removable denture is taken off, since the anterior part is fixed and the edentulism is less visible.

Dental implants can play a major role in terms of biomechanical support. A dental implant would act as a terminal abutment in a Kennedy

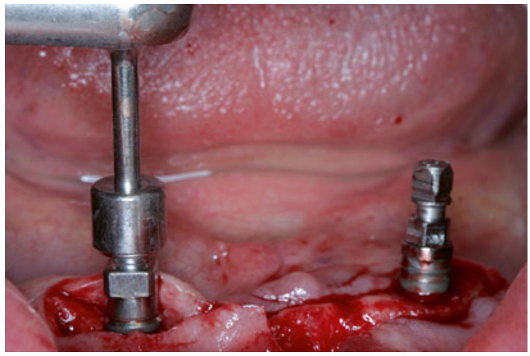

Fig. 17.4 Two interforaminal implants (mandible)

Fig. 17.5 An implant-supported anterior fixed bridge with extra coronal precision attachments

Class III situation. As pointed out earlier, one of the most challenging situations is the Kennedy Class II when there are abutments on only one side of the arch and the long lever arm to the unilateral edentulous side causes insufficient stability; an implant placed strategically convenient would improve the fulcrum line position.

Before making the decision, the oral condition of the patient and the exigency for implant use must be thoroughly overthought, and justifiable indications should be determined. As an example, in a Kennedy Class I situation, where only molars are missing, it would be an unnecessary attempt to place implants for RPD support, since the patient could receive a fixed solution with the two implants. Similarly, a short edentulous gap would be a weak indication for an implant placement. Implants offer the advantage of not requiring the use of the teeth as prosthetic abutments and thus do not increase the functional burden on the natural dentition. Implants can eliminate the

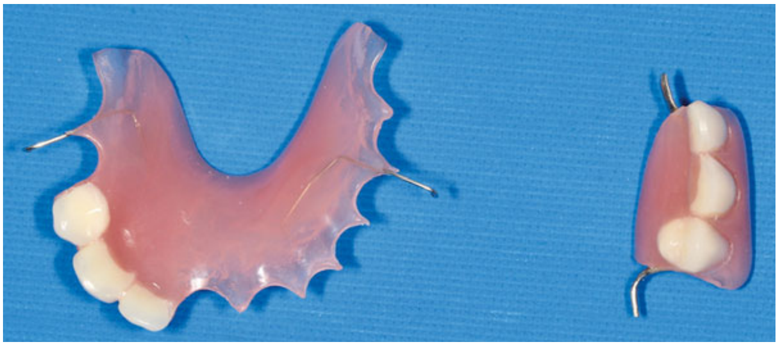

Fig. 17.6 It is important to design the temporary denture with cross-arch stabilization, even in Kennedy Class III situations without any modification. The tiny design in comparison might appear more comfortable due to smaller volume, but during use, it will be difficult to keep it stable

necessity of involving adjacent teeth in the reconstruction, but when nonetheless the adjacent teeth are in need of restoration, a conventional prosthesis should be considered primarily, especially in short span spaces. The costs as well as the invasiveness of the surgical intervention associated with implants must always be considered. On the other hand, for longer span modification spaces with four or more missing teeth, a greater challenge for natural tooth-supported fixed prostheses is existing. In these cases, the tooth-supported fixed partial denture is not an alternative anymore. The clinician will aim either a CRPD or an implant-supported solution. As mentioned in several studies, the residual ridge resorption can be greater with longer spans, which will increase the need for augmentation procedures if implants are intended. Besides the additional costs with implants, the increased morbidity associated with augmentation procedures can also limit universal application. Only for this reason, an implant manufacturer has developed an implant material with a much higher strength, namely, a titanium-zirconium alloy, allowing the use of narrow diameter implants in the posterior. Although not an evidence-based fact yet, short implants are much more often successfully used compared to a decade ago, in cases with insufficient bone volume, thus avoiding the necessity of invasive augmentation procedures. Looking at this issue from another point of view, it must be pointed to the information that implants in large edentulous spans may promote bone preservation owing to peri-implant remodeling stimulus; thus, it could be discussed that implants do not only bring additional costs and morbidity but also long-term benefit. A troublous feature of IARPDs is the need for an osseointegration period, thus the need to fabricate an interim prosthesis. The provisional brings additional costs and a relatively uncomfortable time interval for the patient. It is important to design the temporary denture with cross-arch stabilization, even in Kennedy Class III situations without any modification. The tiny design in comparison (Fig. 17.6) might appear more comfortable due to smaller volume, but during use, it will be difficult to keep stable. In the planning of an interim removable partial denture, the author of this chapter prefers the Adams clasp, since it guarantees a certain support, because there are no occlusal rests keeping the denture from tissue-ward movement. The alternative would be immediate loading of the implants in order to avoid an additional denture for provisionalization of the partial edentulism situation. Immediate loading in the edentulous mandible has been well documented. Although the maxilla is still showing a question mark, there are good data showing that immediate loading of the edentulous maxilla may also be feasible if bone quality is suitable. There are a lot of techniques described in literature offering possibilities to achieve good stability even in cancellous bone. In spite of these facts, the immediate loading is not a routine clinical application and should be considered with caution.

It should be kept in mind that the use of implants as a valuable help for RPDs does not allow to leave main principles of design such as the necessity of seats or rigid main connectors.

17.2 Important Hints for Clinicians

Main indications for IARPDs:

- In order to help out the patient after the loss of several dental implants with a step back solution (from fixed to removable)
- When the remaining dentition is not suitable to be used as abutment teeth and/or patient does not wish to lose all the teeth, even when these are not strategically suitable
- In cases where implants are placed gradually in a certain time period and there is a time interval where a transitional RPD is needed
- Advanced ridge resorption in edentulous areas, making additional stability and retention measures necessary
- In cases where surgical augmentation procedures for placement of all needed implants are contraindicated
- In cases where the clasps should not be visible and the denture base is desired to be smaller
- In cases where the jaw relation is inconvenient and the placement of the artificial teeth in intercuspal position (e.g., too far buccally) threatens the denture stability
- In a few cases where extremely angulated implants cannot be treated by conventional methods
- Patient desires

Contraindications for IARPDs:

- Cases where no surgery may be performed
- Patients not able to use any removable denture
- Situations where interocclusal or interarch distance does not allow the placement of an implant attachment

Advantages of IARPDs:

- Enhanced esthetics by elimination of clasps and compensation for loss of supporting tissues (assuring better lip support).
- Change of the fulcrum axis position possible.
- The forces on remaining teeth may be reduced.
- In free-end partially edentulous arch situations, vertical support may be increased.
- Improved retention and stability.
- The arrangement of the insertion path is less problematic with implant abutments.
- Depending on attachment type, the maintenance may be easier.
- Reduced pressure or trauma on supporting tissues.
- Preservation of the bone around implants through delayed alveolar atrophy in edentulous areas.
- Compared to complete edentulism, the remaining teeth help preserve the proprioception.
- It may reduce the need for indirect retention.

Disadvantages:

- Increased cost
- Additional surgical interventions.
- Increased treatment time.
- Multidisciplinary approach necessary.
- The treatment is more technique sensitive.
- Depending on attachment type, the maintenance may be more difficult.
- In some instances, the denture production stages may be more complicated.
- Osseointegration period.

17.3 Main Alternatives and Different Treatment Modalities with Dental Implant Use as RPD Support

17.3.1 Edentulism

Two or three implants placed in the mandibular interforaminal region for a canine-to-canine bridge (Fig. 17.4) and support of a posterior RPD. This solution can be a valuable remedy in case of loss of one or more implants in a fixed planning. In a conservative approach, the remaining implants can be used for a step-back solution and for support of an RPD. The advantage of this modality is the transformation of the edentulous situation to a more favorable Kennedy Class I.

The permanent presence of a fixed anterior bridge (Fig. 17.5) even after removal of the removable denture can give an esthetical confident feeling and may be preferred by a not to be underestimated number of patients.

17.3.2 Kennedy Class I and/or II Situation

There is no consensus on the position of the implants to be placed in order to achieve stability and retention in free-ending situations such as the Kennedy I and Kennedy II classifications. A popular location for the placement is in the posterior end, around the second molar area. On the other hand, there are clinicians who prefer the location next to the tooth neighboring to the free end as the most suitable position.

The distal extension mandibular RPD comprises some difficulties in use, partly due to the varying resilience characteristics of abutment teeth and mucosa, thus transfer of occlusal load. These difficulties can decrease patient satisfaction and even cause patients to quit the use of removable dentures. In the case of a Kennedy Class I situation, where canines are missing and only the central and lateral incisors are present, implants in the canine positions can have several important roles: support, retention without visible elements, and protection of the remaining teeth (Fig. 17.7). The placement of implants adjacent to distal abutment teeth, in general (Fig. 17.8), is additionally useful if a future fixed restoration is intended. This solution allows delivery of a provisional or permanent RPD without clasp showing and later changing to a fixed bridge after adding the necessary implants in the posterior. The Kennedy Class II partially edentulous situation is characterized by a unilateral extension. Clinicians should be aware that frequently RPDs prescribed especially for patients with a Kennedy Class II situation are not being used. It is well known that the Kennedy II cases represent a difficult group from planning and use point of view. One of the reasons is the insufficient indirect retention causing the shift of the most posterior part of the RPD resulting in food trapping or giving the patient a feeling of discomfort. The use of one or two dental implants here may be helpful in eliminating these problems (Figs. 17.9, 17.10, and 17.11). Although not very common, the mid-span location may also offer various advantages (Fig. 17.12). Placement of the implant at either extreme of the edentulous gap may cause a greater tipping effect and should be taken into consideration. However, it may be discussed that the ideal indirect retention effect could fail and the implant

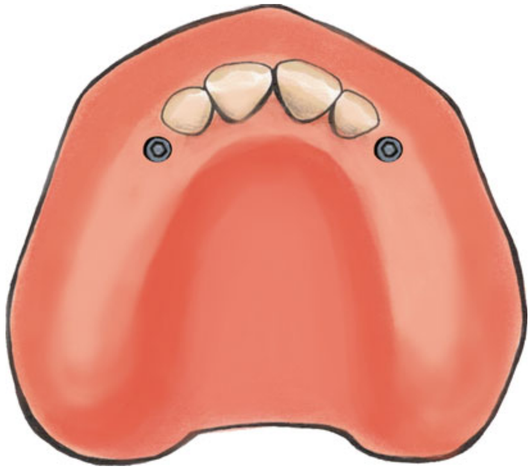

Fig. 17.7 In the case of a Kennedy Class I situation, where canines are missing and only the central and lateral incisors are present, implants in the canine positions can have several important roles: support, retention without visible elements, and protection of the remaining teeth

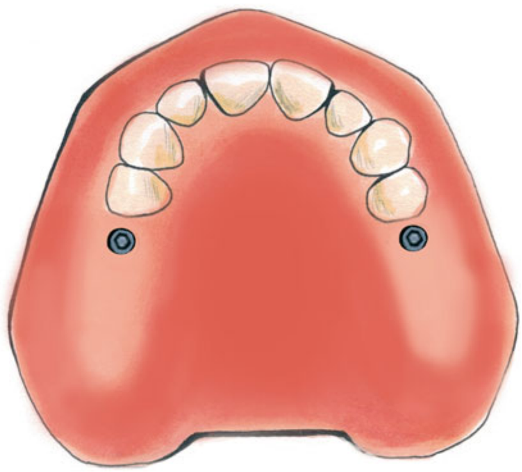

Fig. 17.8 This solution allows delivery of a provisional or permanent RPD without clasp showing and later changing to a fixed bridge after adding the necessary implants further posteriorly

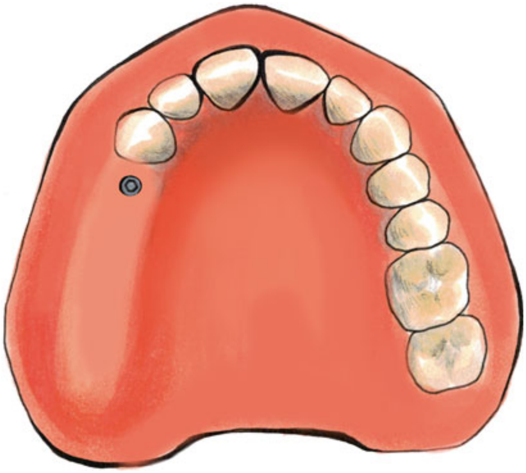

Fig. 17.9 Due to insufficient indirect retention causing the shift of the most posterior part of the RPD resulting in food trapping, patients may feel a discomfort in Kennedy Class II situations. An implant placed distal to the last abutment tooth may help prevent this inconvenience

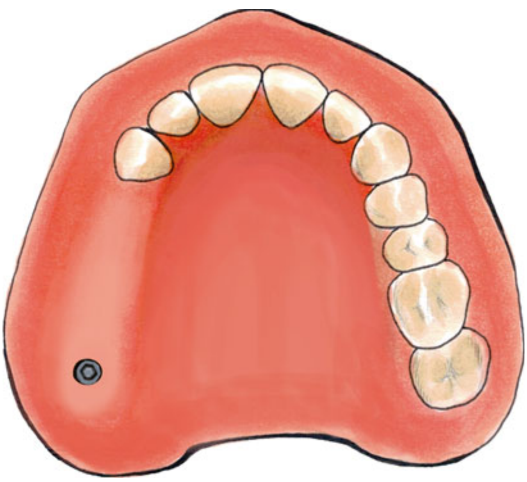

Fig. 17.10 If the visible clasp is not an issue and the distal abutment is a dependable tooth such as the canine, the implant can also be placed in the second molar position

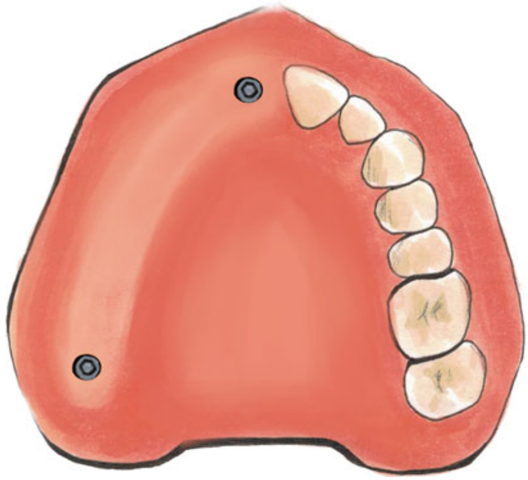

Fig. 17.11 In cases where the edentulous span is wide and covers unilaterally a whole quadrant, two implants should be taken into account

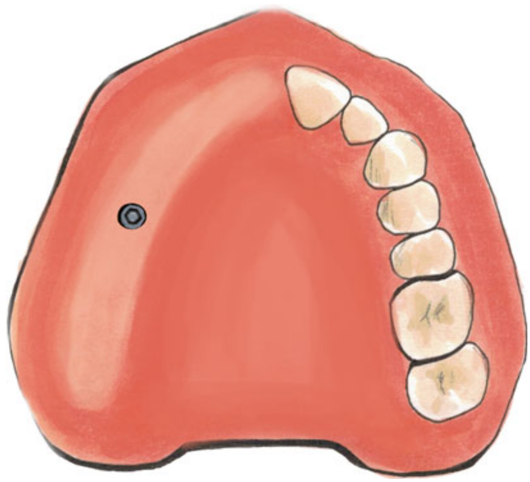

Fig. 17.12 The mid-span location is not common, but it may also be considered

attachment will be subject to larger torsion movement, eventually causing more frequent complications. This alternative with the interim positioned implant would be probably valuable as a step back solution after loss of several implants, having been placed for a fixed solution. All discussed considerations apply to both situations, Kennedy Class I and Kennedy Class II. Placing four implants (Fig. 17.13) may be considered a bit too luxurious in a Kennedy Class I situation and can be criticized but delineates a very good transitional situation for a later fixed solution. In the case of Kennedy I and II situations, the fulcrum axis can be moved to distal by implants placed in the molar region, and additional support and retention may be obtained in order to increase patient comfort. Implants placed in the area of the second molars would change the Kennedy Class I situation to a more favorable

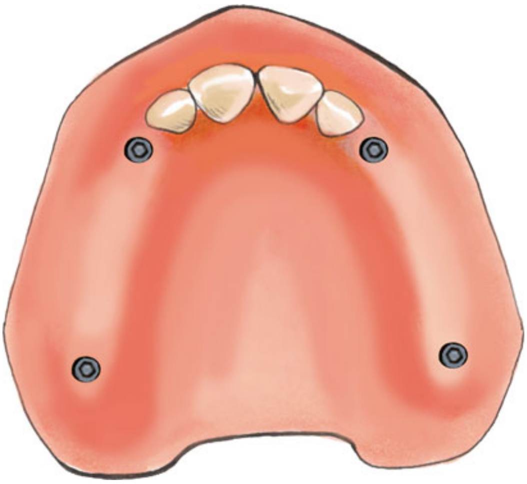

Fig. 17.13 Placing four implants may be considered a bit too luxurious in a Kennedy Class I situation and can be criticized but delineates a very good transitional situation for a later fixed solution

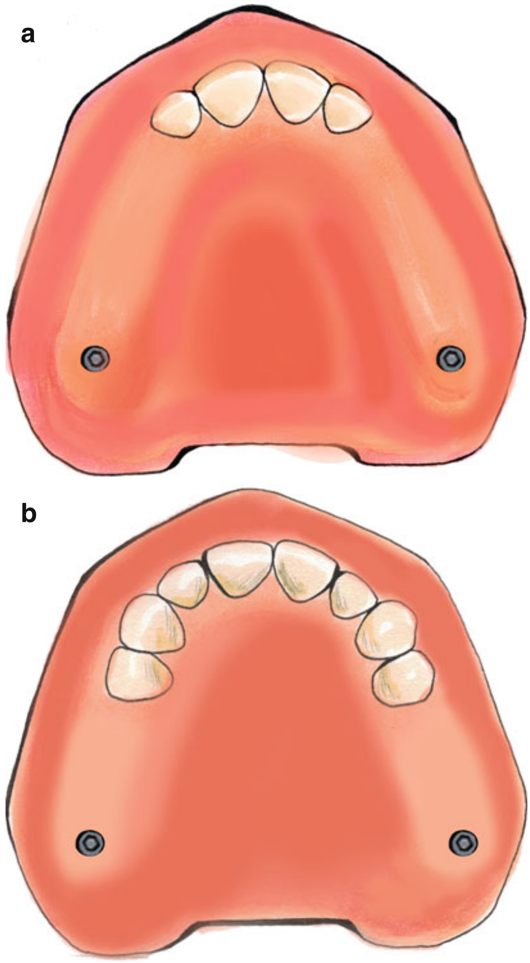

Fig. 17.14 (**a**, **b**) Implants placed in the area of the second molars would change the Kennedy Class I situation to a more favorable Kennedy Class III

Kennedy Class III (Fig. 17.14a, b). The results of a finite element analysis study, however, showed a tendency to more displacement of the denture, when implants were placed in a second molar position. Accordingly, a more central position in the arch, such as the first molar region, was suggested. In another study, where a bidimensional finite element method had been used, it was found that approximating the implant to the abutment tooth caused the best distribution of stresses on the analyzed structures. On the other hand, a more central position, e.g., the first molar position, had decreased the dislodging of the denture, compared to the further distal or most mesial positions. In the case of inadequate posterior alveolar ridge, the placement adjacent to the distal abutment tooth, at the most mesial location, is recommended. As abovementioned, this position can also be advantageous for possible future use in fixed implant-supported prosthesis or in order to improve esthetics by avoiding the use of a retentive clasp.

Although the optimal length and diameter of the implants associated with the RPD have not been determined yet, a probable disadvantage could be that short implants must be used in case of lack of sufficient bone height, when located as distally as possible to provide maximal support and stability, in Kennedy I or Kennedy II cases, due to local anatomy. In many Kennedy Class I or II cases, the remaining alveolar bone height above the mandibular canal is insufficient for implant placement of conventionally accepted length. The frequency of the use of short implants is growing, and today, implants of even 4 mm length are available on the market. However, the long-term success will have to be shown in clinical studies in the coming years. This treatment modality would be even more suitable for cases with existing canines, where clasps can be placed more securely because of better support from their stronger roots. Otherwise, e.g., when

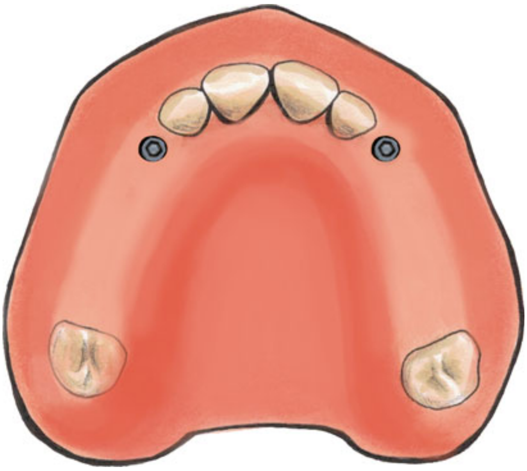

Fig. 17.15 If a Kennedy Class III situation already exists, implants can be used for several purposes, such as shortening a too long edentulous space, in case of unreliable compromised weak abutments (e.g., root canal treated or post-cored teeth) or when clasps are to be eliminated

canines are missing and lateral incisors or weakened premolars are aimed, avoiding direct retainers applying unfavorable lateral displacing forces, especially in endodontically treated abutments, would be specifically beneficial.

17.3.3 Kennedy Class III Situation

If a Kennedy Class III situation already exists, implants can be used for several purposes, such as shortening a too long edentulous space, in case of unreliable compromised weak abutments (e.g., root canal treated or post-cored teeth) or when clasps are to be eliminated (Fig. 17.15). The best position for the implants in these cases is adjacent to the abutment teeth. However, it should be known that implants are only used seldom in Kennedy III cases.

17.3.4 Kennedy Class IV Situation

In the Kennedy Class IV partially edentulous situation, the arch has a single, anterior edentulous gap that crosses the midline, and the remaining teeth create the butting. The long edentulous span in extreme Kennedy Class IV cases where only a few molars exist can create a challenging fettle, complicating the use of a partial denture (Fig. 17.16). In such cases, a few dental implants, e.g., two implants in the canine positions (Figs. 17.17 and 17.18), could give the dentures a very reliable stability as well as retention. The position of the two implants to be placed is a subject of discussion. In general, clinicians use preferably symmetrical canine positions for the two interforaminal implants, perhaps still as the result of experience with overdentures (OVDs) supported by natural teeth, since the mandibular canines frequently are the last natural teeth remaining due to better intrabony support and are suitable as OVD abutments. However, other arguments should be kept in mind too. Moving the implants slightly anterior to the lateral incisor position could create several advantages in certain situations. When using a bar connecting the two implants in a situation with a tapering arch form, the canine positioned implants could cause cantilevering to the anterior to avoid encroaching on the tongue space and floor of the mouth, which may increase the risk of screw loosening or fracture due to bending moments involved with cantilever loading. In this manner, the implant placement slightly more to the anterior will definitely reduce the potential need for off-center bar placement. It is enunciated that

Fig. 17.16 In extreme Kennedy IV cases where only a few molars in the most distal exist and the long edentulous span can create a challenging fettle complicating the use of a partial denture

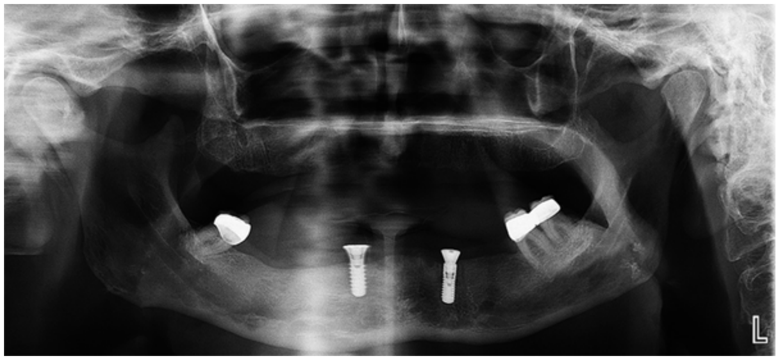

Fig. 17.17 A panoramic radiography showing two interforaminal implants in an extreme Kennedy Class IV situation

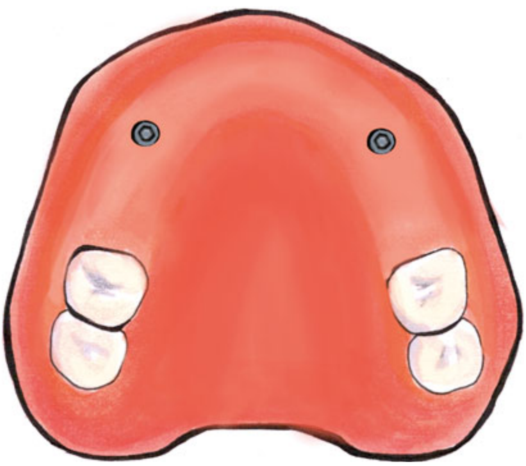

Fig. 17.18 In extreme Kennedy Class IV cases, a few dental implants could give the dentures a very reliable stability as well as retention

Fig. 17.19 Two anterior implants giving anterior support and retention in a maxillary Kennedy IV situation

another advantage of a more anterior placement of the two implant OVD abutments is that this placement reduces the tendency for the mandibular denture to rotate around the fulcrum created between the two implant abutments. It is claimed that if the implants are placed in the canine position, there may be a tendency for the distal denture bases to lift when the patient incises with the anterior teeth. This could be particularly problematic when the retentive components of the OVD attachment system are designed to permit rotational freedom of movement around the implant fulcrum. Implant placement in the lateral incisor position could reduce the anteroposterior distance from the incisal edges to the rotational axis between the implants, which would be a factor inhibiting the tendency for the denture to lift to the posterior and thereby increasing its stability. In the author's opinion, if single attachments are planned to be used, this argument is not eligible anymore. On the contrary, there are clinical studies showing the trend for better patient satisfaction scores, the more distal the implants are placed. Independent from the position, the anterior support and retention via implants should not be neglected as a viable option in mandibular as well as maxillary Kennedy IV situations (Figs. 17.19 and 17.20a, b). As very well known, an important factor in the decision-making of attachments is the space needed for the retentive components. If there is insufficient interarch (interocclusal) space, a locator is a better choice compared to a bar-and-clip type of attachment. A controversial issue worth to study further as a treatment modality would be the use of a single mandibular midline implant as an OVD abutment to increase mandibular denture retention and stability,

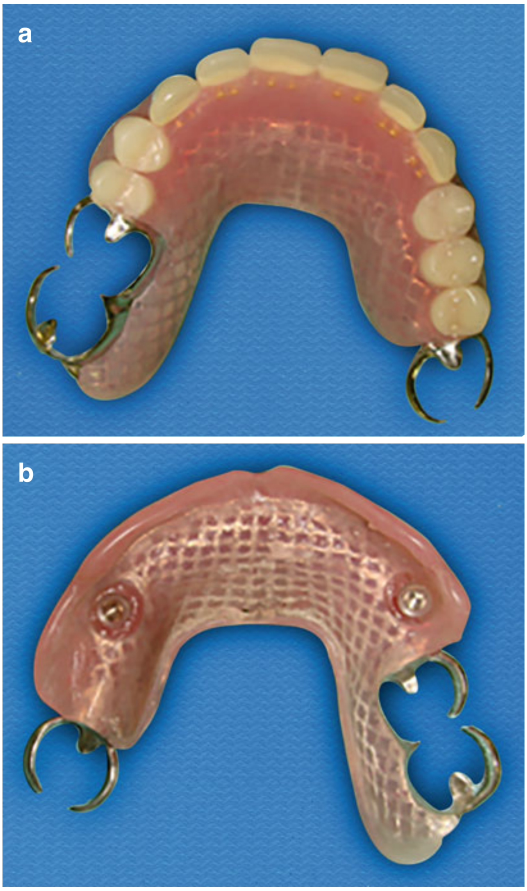

Fig. 17.20 (**a**) Occlusal view of the maxillary Kennedy IV removable partial denture. (**b**) Implant-supported anterior retention elements embedded in a removable partial denture

especially inhibiting the tendency for the posterior extensions of the OVD to lift during incising. A single implant may be nearly as effective as two anterior implants in this regard and could reduce treatment costs considerably.

Another argument is that if later a fixed solution in the form of interforaminal five implants supporting a detachable denture is aimed or should the patient desire additional implant therapy in future in a severely resorbed mandible, the placement of two implants in the lateral incisor positions allows for future placement of implants in midline and as far distally as the mental foramina allow bilaterally. It is often stated that placement of three additional implants is feasible when the original two implants are placed in the lateral incisor positions. This, of course, does not comply in a mandibular edentulism case, where there is sufficient bone volume for implant placement in the posterior. Here, the ideal implant positions (if six implants are planned) would be bilaterally the canines, first premolars, and first molars, and the canine position would be very convenient.

In cases of severe alveolar atrophy hindering even the placement of two interforaminal implants, a single symphyseal implant was pointed out in a study to play a pivotal role to improve the integrity of the principle abutments and alveolar bone support in long-span Kennedy Class IV cases. The symphyseal region is generally known to have the greatest available bone height, thick dense cortical plates, and dense trabecular bone making it an ideal location for an implant treatment.

Different than in the other Kennedy classifications, in a Kennedy IV situation, an RPD has superiority vs. fixed solutions; especially in cases with severely resorbed alveolar ridges, the buccal flanges of the dentures are capable to give better lip support and assure a better esthetic result. If the retention and stability in these critical cases can be improved by dental implants, it is to be expected that patients often prefer the removable alternative.

Long-term studies evaluating the success of dental implants used for RPD support revealed very high survival rates, minor prosthetic complications, and superior patient satisfaction. On the other hand, there are generally only poorly reported clinical studies in the literature, and quantitative systematic reviews or meta-analyses are missing due to the lack of randomized or non-randomized controlled trials. For this reason, there are no settled guidelines dictating the number and location of RPD supporting dental implants yet, and the clinicians have to act obeying their sense of clinic and own experience. As an example, there is no consensus on the most favorable implant position in a Kennedy Class I or II situation. While some authors recommend the second molar position (most distally possible position) to transform the situation to a much more comfortable Kennedy Class III case, others suggest a more central position such as the first molar position against a tendency to displacement. The author of this chapter advises to choose the implant position, taking cognizance of the available bone volume for optimal implant size. In a distally placed implant situation, a clasp has to be used at the most distal abutment tooth. If the most distal abutment tooth is an incisor, the strategy of transforming to a Kennedy Class III situation has to be given up and the implant position chosen at the most mesial part of the edentulous span. This brings an esthetic advantage and also protects the generally weaker roots of incisors from lateral overload.

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18 Useful Facts Concerning Implant-Assisted Removable Partial Dentures

Hakan Bilhan

Evidence from long-term clinical follow-up is needed, but it can be speculated that the frequency of complications and maintenance requirements of implant-assisted removable partial dentures are to be expected similar in number as in conventional removable dentures. Mainly the most often encountered complications are related to the retention mechanism. Generally, there is an agreement about no observable effect of the attachment design on the incidence of maintenance requirements. Other maintenance requirements would be periodic adjustment of occlusal contacts, changing of artificial teeth, and elimination of possible sore spots. Additionally, in implant-assisted prostheses, peri-implant complications such as periimplantitis may occur from time to time. Although there is a very high success rate, it would be advisable to inform patients thoroughly from the beginning about probable complications as well as expected maintenance requirements and the costs in order to avoid unpleasant confrontations. Possibilities and recommendations related to attachment selection as well as probable complications and maintenance requirements are reviewed and explained in this chapter.

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18.1 Attachments and Different Strategies

The details of the precision attachments were described in an earlier chapter. Attachments may be classified in very different ways. A popular one is dividing them in two groups as “single” and “splinted.” At this time, there is no scientific evidence showing the need for splinting. However, it would rather be advisable to splint the implants in situations of insufficient bone quality and quantity, especially when narrow implants had been placed. As stated in a paper, attachment selection should be directed by the available interarch distance and rather be evaluated at the diagnostic phase. Suitable abutments for implant retention of partial prostheses are:

- Bar attachments.
- Ball attachments (retentive anchors).
- Locator (zest anchor).
- Locator abutments may be recommended because of their availability in different heights in addition to their resiliency and retention. Locator abutment can also be easily repaired and replaced which enhance their durability.
- Telescopic attachments (Figs. 18.1 and 18.2).
- Magnets.
- Crown and bridge abutments.
- These are used in combination with precision attachments fabricated for use with tooth crowns. In order to avoid regular decementation,

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Fig. 18.1 Telescopic gold attachments in the denture

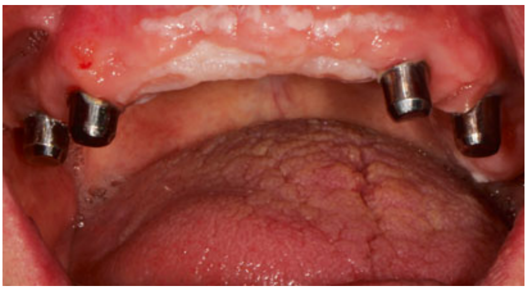

Fig. 18.2 Telescopic abutments intraorally

abutments with occlusal screw retention system may be preferred. An implant-supported crown is also reported as an alternative to be used unilaterally to replace a primary abutment tooth. The crown may also be used without a precision attachment, serving solely as an abutment tooth, having the suitable retention area for a clasp.

- Innovative solutions.
- Titanium shock absorber (TSA) from BoneCare Dynamics NV (Belgium) suggests a slightly improved load damping feature on the implants for highly resilient mucosa supported by the edentulous alveolar crest. This feature may be of special value in cases where short or narrow implants have been used, in order to protect from biomechanical overloading.

As several other issues relate with IARPDs, such as the ideal implant location and size of the implant, the choice of the most suitable attachment system remains mainly dependent to the clinicians' preferences and needs more evidence from research to build up a guideline.

In addition to several abovementioned classification methods of partially edentulous arches, a classification system depending on the Applegate–Kennedy system was described by Misch and Judy, with emphasis on the available bone in the edentulous area for implant placement. This proposed classification had involved four divisions. Divisions A and B were indicating that the bone is available for implant placement, while division C was pointing that there is no sufficient bone for implant placement, and finally division D, where only basal bone is available due to severe atrophy of the edentulous area. A more recent article was suggesting a new classification method with the name "Implant-Corrected Kennedy (ICK) Classification System." The authors used the Applegate–Kennedy system for the explanation of the partial edentulism situation and added the location of the placed or planned implant(s) using the American Dental Association (ADA)'s numbering between parentheses (Fig. 18.3). In this book, the FDI (Federation Dentaire Internationale) system was preferred for numbering the dentition (see Chap. 3).

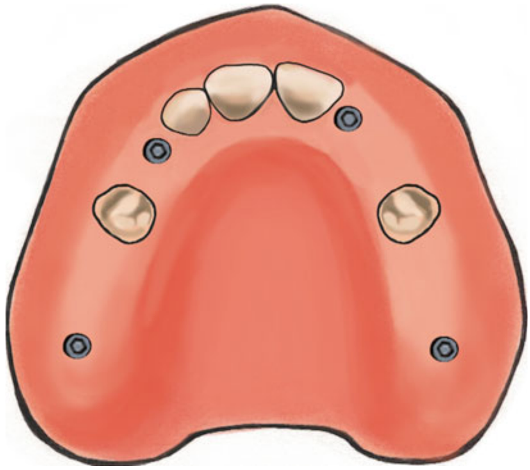

Fig. 18.3 ICK I mod 2 (# 2, 6, 10, 15); if modified to FDI dental numbering system, it would correspond to ICK I mod 2 (# 17, 13, 22, 27)

18.2 Complications and Maintenance Requirements

Long-term studies having evaluated the success of dental implants being used for RPD support revealed very high survival rates, minor prosthetic complications, and superior patient satisfaction. On the other hand, it should be pointed out that there are generally only poorly reported clinical studies in the literature, and quantitative systematic reviews or meta-analyses are missing due to the lack of randomized or non-randomized controlled trials in these cases.

The forces at the pivot points such as the abutments are at maximum level, being even higher with increased occlusal force and base length. In this manner, distal extension RPDs may show a risk of failures more frequently in the supporting elements of denture or abutments. Shear forces lead to a bending moment as a function of distance, thus leading to instability of distal extension RPDs. Although it was reported that implants might tolerate higher forces than abutment teeth, complications will inevitably occur in time.

Additional to general partial denture complications, the IARPD complications or maintenance needs tend to concentrate more in the retention mechanism. Similarly, the most frequent complications related to implant OVDs that have been reported in the literature are loss of retention or damage to the retention mechanism, fractures of the restorative material, and need of rebasing or relining.

There is an ongoing debate about the influence of attachment type on later technical complications in implant OVDs, although only a few studies have compared treatment outcomes with different attachment systems of OVDs. It is well recognized that attachments of OVDs on implants lose retention after some time. Fatigue and wear of the material could be another factor causing complications with retention loss. While food chewing, forces from three directions appear and may cause rotation or rocking, thus clinically leading to plastic deformation of the matrices, resulting in a reduction of retention or dislodgement of the clip. Most frequently, the wear happens in the female part of the retention mechanism; however, it is not rare that the male part is subject to detrition.

Although there is no unanimous opinion, generally, there is an agreement about no observable effect of the attachment design on the incidence of maintenance requirements. On the other hand, several authors have reported that prosthodontic maintenance requirements with ball attachments were higher, particularly during the first year. In a review, it was pointed out that a dislodged, worn, or loose matrix or its respective housing was more common after the first year with ball retainers and the most common repair was retentive component replacement. The results of another study focusing mainly on the comparison of the retention mechanism complications showed that with resilient attachments, the frequency of broken, loose, or lost bar clips and female retainers of ball anchors had been significantly higher. The rigid bar, on the other hand, had required significantly more retightening of the female part during the first 5 years. Another maintenance requirement is the need of relining of the denture base of the RPD. It is speculated by several authors that OVDs with rigid attachments show less need to be relined. In the same way, it could be speculated that the implant could help preserve the surrounding alveolar bone and reduce the need for relining. In the author's view, the choice of attachment system should be left to the predilection of the clinician, if the path of denture insertion is parallel to the implant axis. Otherwise, a system such as the telescopic attachment, being able to compensate the angle differences, is to be recommended, in order to avoid early wear of the retentive parts. If there are several implants, bar attachments may help to compensate for severely malpositioned implants, too. Although the manufacturer and some authors praise the locator abutment and attachment system for allowing compensation of up to 40°, our clinical experience shows else. In case of angular deviation from the path of insertion, the matrice as well as the patrice can undergo severe wear and lose retentive properties in a very short time. Too often, maintenance requirements of a prosthesis can damage the confidence of the patient and may lead to giving up its use.

Other maintenance requirements would be periodic adjustment of occlusal contacts, changing of artificial teeth, and elimination of possible sore spots. A high incidence of periodontal disease and tooth decay has been reported in CRPD wearers, attributed mainly to a lack of motivation and compliance with adequate oral hygiene. Patients should be advised of their role in the maintenance of the IARPD, and a definite follow-up protocol is mandatory to obtain satisfactory long-term results. It must be discussed what influence the missing proprioception in IARPD patients may provoke. The missing feedback may cause the patients to bite or chew stronger, whereas this overload could have a more detrimental effect on these cases since implants will inhibit the resilience and forces will concentrate at certain sites. Weak parts of the IARPD such as the acrylic junction with the attachment matrice then are more prone to fracture. Long-term clinical follow-up studies will give valuable data concerning the difference between IARPD and CRPD complications.

It could be expected from learned clinical notion that the placement of short and/or narrow implants may create a biomechanical handicap, but long-term clinical follow-up studies are necessary to be able to draw reliable conclusions. The width of the implant could be a decisive factor too. It is known that manufacturers do not recommend the use of implants with diameters less than 3.5 mm in the posterior region or as single standing attachment support because of the danger of fracture. In this manner, the author exhorts the use of stronger implants having a width of at least 4.0 mm for this purpose. On the other hand, there are authors affirming that it is expected that the implants used to support an RPD can be shorter with smaller diameter. As mentioned above, an implant manufacturer has developed an implant material with a much higher strength, in order to be able to provide clinicians with a narrow alternative. Short implants are more often used, compared to a decade ago, although evidence for equal success as in longer implants is still lacking.

In some scientific research articles, resilient attachments in combination with IARPDs have been recommended. A low-profile attachment may be preferred to decrease the off-load forces to the implants. At the most distal of the denture flange where the base thickness is limited, a high abutment could cause a bulge.

The technical complexity of an IARPD may increase the probability of technical complications and some costs. On the other hand, the provided stability and different retention mechanisms are capable to reduce the often-mentioned high incidence of periodontal disease and dental caries, extending the survival period of the remaining dentition. Additional research and long-term clinical follow-up studies will be able to give valuable data concerning the influence of dental implants on the prognosis of the abutment teeth, supporting soft tissue and alveolar bone, due to decreased loading.

Although no scientific data is available yet, there is still a huge group of scientists and clinicians believing that the biomechanical behavior of the teeth and implants under functional loading is similar. However, the majority of in vitro, in vivo, and clinical follow-up studies indicate that the reaction of implants to load is different than traditionally taught in textbooks. Issues such as the influence of crown–implant ratio, cantilevers, and lateral forces are to be debated from a different point of view in implant dentistry. The efficacy of stress-breaking on tooth-implant supported prosthesis was evaluated in a numerical simulation study, and it was reported that the stress-breaker keyway device function becomes obvious only when occlusal forces act on the natural tooth. In the opinion of the author of this chapter, the supporting implants do not need to be protected from functional loading forces with special measures. The implants seem to tolerate a great amount of load unless they are underdimensioned in size or are placed in inadequate bone. The prejudices from the 1980s concerning implant length have been revolutionized by clinical experience and scientific, evidence-based data, and today, implants of down to 6 or even 4 mm length are being used instead of 16–17 mm earlier. Literature clearly defines that functional loading forces do not have a detrimental effect on osseointegration process, and it was shown that in single implants, off-axial loads do not lead to marginal bone loss. The knowledge regarding the response of the peri-implant bone when the dental implant is excessively loaded is limited, and the level of evidence is poor. With animal experimental studies showing conflicting results, it is unclear whether occlusal overload might cause marginal bone loss or total loss of osseointegration to already osseointegrated dental implants when the applied load exceeds the biologically acceptable limit. This biological limit is also unknown. Furthermore, higher remodeling activity of the peri-implant bone is found around implants subjected to high loading forces. In this manner, we do not necessarily need to recommend a resilience mechanism in order to protect the RPD supporting implants from overloading during denture function.

Although there is a very high success rate, it would be advisable to inform patients thoroughly from the beginning about probable complications as well as expected maintenance requirements and the costs in order to avoid unpleasant confrontations.

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Part V

Maintenance and Post Insertion Problems of Removable Partial Dentures

Postinsertion Problems

19

Onur Geckili

19.1 Definitions

Acrylic resin Any of a group of thermoplastic resins made by polymerizing esters of acrylic or methylmethacrylate acids

Alveolar bone The bony portion of the mandible or maxillae in which the roots of the teeth are held by fibers of the periodontal ligament

Articulating paper Ink-coated paper strips used to locate and mark occlusal contacts

Deflective occlusal contact A contact that displaces a tooth, diverts the mandible from its intended movement, or displaces a removable denture from its basal seat

Gag An involuntary contraction of the muscles of the soft palate or pharynx that results in retching

Hard palate The bony portion of the roof of the mouth

Incisive papilla The elevation of soft tissue covering the foramen of the incisive or nasopalatine canal

Occlusal prematurity Any contact of opposing teeth that occurs before the planned intercuspation

Occlusal reshaping The intentional alteration of the occlusal surfaces of teeth to change their form

Pressure-indicating paste Any substance applied to a dental prosthesis, which, when seated on a structure, demonstrates the adaptation of the prosthesis to the structure it opposes

Remount procedure Any method used to relate restorations to an articulator for analysis and/or to assist in the development of a plan for occlusal equilibration or reshaping

Residual ridge crest The most coronal portion of the residual ridge

Retention That quality inherent in the dental prosthesis acting to resist the forces of dislodgment along the path of placement

Stability The quality of a removable dental prosthesis to be firm, steady, or constant, to resist displacement by functional horizontal or rotational stresses

Trauma An injury or wound, whether physical or psychic

Patients rehabilitated with RPDs should be recalled the day after the insertion of the prosthesis. If anything more than a minor tissue damage is observed, they should be seen in the following 2 or 3 days to ensure the healing of the damaged tissues, 1 week after, and every 6-month interval for periodic oral evaluations. The patients susceptible to caries or having periodontal problems may be recalled more often.

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The recall visits should be long enough to give the patient confidence that required adjustments will be provided and to give warning that an appointment is needed for future adjustments without intruding the clinician's routine schedule.

It is not feasible to make an intraoral examination immediately after the patient is seated. The clinician should ask questions about the function, esthetics of the RPDs, and the condition of the remaining dentition prior to intraoral examination. Intraoral examination should be performed in detail with and without the RPDs even if no complaints exist afterward. It should be remembered that some minor tissue damages or premature occlusal contacts which are not perceived by the patient can be detected and corrected by the clinician, and future pain and discomfort problems may be prevented. The problems associated with wearing an RPD may be classified into six categories:

- Pain and discomfort related to soft tissues or remaining teeth
- Difficulty seating or removing the RPD
- Lack of retention and stability
- Functional problems
- Esthetic problems
- Compromised periodontal health and mucosal lesions

19.2 Pain and Discomfort Related to Soft Tissues or Remaining Teeth

Pain and discomfort may be associated with the remaining teeth, soft tissues surrounding the denture base, or both and classified as one of the most usually seen RPD postinsertion problems. The areas of tissue trauma may be in the incisive papilla, hard palate, residual ridge crest, the peripheral borders of the RPDs, or the mucosa not covered by the RPDs such as lips and cheeks. Tissue trauma reveals as increased redness or translucency in the oral mucosa. Increased redness is the symptom of the ulcerations, and a translucency may occur just before ulceration exists. Overextension of the denture bases and the pressures on the fragile tissues such as incisive papilla or occlusal prematurities are the main causes of these ulcerations. Ulcerations due to tissue trauma (Fig. 19.1) develop generally at the initial recall appointments and can be solved easily by relieving the denture base parts touching the pain area. In case of overextension, ill-fitting RPDs, or acrylic irregularities, the areas can be identified by the aid of an indelible pencil or pressure-indicating paste. Nevertheless, it is much better to prefer an indelible pencil because using a pressure-indicating paste or cream for determining these areas may cause faulty results as the paste is easily displaced due to its softness. The indelible pencil is used to mark the ulceration area (Fig. 19.2), and after the area is transferred to the RPD (Fig. 19.3), these parts are gently removed using a tungsten carbide bur.

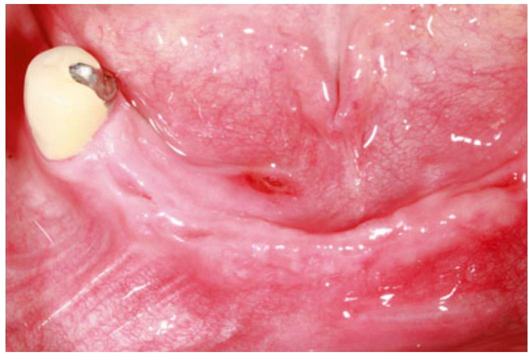

Fig. 19.1 An ulceration due to tissue trauma caused by the overextension of the lingual border of an RPD

Fig. 19.2 An indelible pencil may be used to mark the ulceration area

The ulcerations appearing on the residual ridge crests are usually due to occlusal prematurities; but they may also be because of the irregularities of the acrylic resin on the intaglio surface of the

Fig. 19.3 The ulceration area is transferred to the RPD. The marked parts may be easily removed using a tungsten carbide bur afterward

Fig. 19.4 A rest and clasp assembly not fully seated will probably apply nonaxial forces to the abutment tooth

denture base. These irregularities may be recognized by clinicians by examining the denture base with fingertips and eliminated before the delivery of the RPDs. Additionally, denture base roughness can be corrected after using a pressure-indicating paste and identifying the exact areas causing the discomfort. After the adjustment, the pressure-indicating paste should be reapplied for verification. Topical agents may be used to relieve pain and stimulate healing.

19.3 Difficulty Seating or Removing the RPD

The difficulties in seating or removal of an RPD are usually seen in the insertion period, but this complaint may also appear after the RPD has been in use for some time. This complaint may be classified into three categories.

19.3.1 Incomplete Seating of a Rest and Clasp Assembly on the Related Abutment

If the rest and clasp assembly is not fully seated on the abutment (Fig. 19.4), it may apply nonaxial forces to the abutment. These forces may cause significant discomfort, tooth movement, or metallurgical fatigue of the clasp arms due to being active all the time. This may usually occur because of design errors. If a proper path of insertion was not designated at the time of treatment planning, the RPD may not fully seat on the abutments. The guiding planes should be carefully examined, and if there is a minor incongruity, the RPD may seat after preparing the guiding planes. If it is not possible to seat the RPD by modifying the guiding planes, refabricating procedure may be the only solution.

19.3.2 Seating Problems Due to Pronounced Soft Tissue Undercuts

Soft tissue undercuts may create problems if any component of an RPD passes over them during insertion or removal of the prosthesis. These problems usually involve pain and discomfort due to injuries of these soft tissues. These soft tissue undercuts should be surgically corrected prior to definitive treatment (see Chap. 6); but if they appear after the treatment, the RPDs may be rebased, relined, or remade according to the extent of the surgical procedure.

19.3.3 Patient-Related Factors

Patient-related factors may be inability to manipulate or distortion of the RPD after usage. Elder RPD users may have systemic neurologic disorders. Therefore, it is not feasible to use complicated RPD designs which have more than one path of insertion. It is very important to show the patient how to insert and remove the prosthesis and ask him/her to manipulate with the practitioner in the first and the following early appointments. Distortion of the RPD may occur if the patient tries to tighten the RPD or uses the clasps while insertion and removal. The distorted clasps may be changed with wrought wires or cast clasps by the laboratory after making an impression with the RPD.

19.4 Lack of Retention and Stability

Retention or stability loss of an RPD may originate from the following situations:

1. Broken clasps or loss of the precision attachments
2. Decrease in the function of the clasps or precision attachments
3. Overextended or underextended denture bases
4. Deflective occlusal contacts

Retention or stability loss may be due to one or all of these situations. The clinician must examine the origin of the looseness and make the appropriate treatment.

19.4.1 Broken Clasps or Loss of the Precision Attachments

Broken clasps are usually due to fatigue of the RPD components and will be discussed in detail in Chap. 20.

19.4.2 Decrease in the Function of the Clasps or Precision Attachments

Function of a clasp may decrease after some time of usage because of multiple insertion and removals performed by the patient and this problem may be easily solved by bending the retentive arms into the undercut areas with the aid of an appropriate plier (Fig. 19.5). The bending force are generally applied vertically in order to reach the undercut area properly. However, excessive bending should be avoided in order not to cause an accelerated fatigue of the clasp. Clasps may not function properly in case of wear of the abutments due to caries (Fig. 19.6), abrasion, or erosion on the facial or proximal surfaces or because of patient misuse. However, it should be underlined that these may be the reasons only if the RPD has been designed properly. The design must have been completed using a surveyor for deciding the path of insertion and for tracing the survey line to obtain efficient retentive clasps. If

Fig. 19.5 If the function of the clasp decreases, it can be reactivated using pliers and bending the retentive arm into the undercut area

Fig. 19.6 The clasp assemblies may lose their retentive properties due to caries of the abutment teeth

Fig. 19.7 Precision attachments may lose their retention properties due to wear of plastic components. Worn plastic components (**a**) are removed (**b**) and replaced with new ones (**c**) regularly in accordance with the manufacturer's recommendations

Fig. 19.8 CEKA attachments may be changed to original position or activated using the driver provided by the manufacturer

this procedure has not been employed before, the clasps of the RPD are obliged to be loosened every time. If wear exists on the abutments, the nonfunctioning clasps may be changed to functioning by adding composite material to the teeth surfaces and bending the retentive arms into the deepened undercuts with pliers.

The function of the precision attachments may be abridged in time because of the wear of plastic components, and this should have been told to the patients prior to the insertion of the prosthesis. The consistent replacement has to be a standard process of the planned patient maintenance. The worn plastic components should be replaced with new ones regularly in accordance with the manufacturer's recommendations (Fig. 19.7). Activation of the precision attachments is also possible in some attachment types (Fig. 19.8).

Fig. 19.9 Overextended denture bases may cause the muscles and frena to dislodge the RPDs and may also cause tissue irritation and subsequent ulcerations

19.4.3 Overextended or Underextended Denture Bases

An overextended denture base (Fig. 19.9) may cause the muscles and frena to dislodge the RPD, and an underextended denture base (Fig. 19.10) may affect stability; the RPD may not be stabilized under lateral forces and may result in food entrapment.

Overextended denture base areas should be corrected by using a laboratory bur and the flange should be rounded thoroughly while it is being shortened. Underextended denture base of an RPD may be elongated by relining or rebasing with a suitable functional impression method. However, if the borders are too short to be relined, the denture base of the RPD may be remade by completely removing the resin and the artificial teeth if the framework exhibits a clinically acceptable fit.

Fig. 19.10 Underextended denture bases may affect the stability of the RPDs and food entrapment is inevitable in such cases

19.4.4 Deflective Occlusal Contacts

Deflective occlusal contacts usually affect the stability of the RPDs and therefore should be eliminated. If the deflective occlusal contacts are minor, they may be removed by occlusal reshaping with the aid of articulating papers; but if they are gross, the artificial teeth may be changed following a new interocclusal record. If the RPD is a tooth-supported one, occlusal reshaping should be completed using intraoral methods; but if it is a distal extension RPD, the grinding procedures should be performed using remount procedures with the aid of an articulator. However, it should be emphasized that the final grinding procedures should be completed intraorally to compensate the resiliency of the supporting soft tissues with articulating papers having various thicknesses.

19.5 Functional Problems

Functional problems are classified into five parts in this section as gagging; eating, or chewing difficulties; phonetic problems; tongue or cheek biting; and food impaction or collection on the RPD borders.

19.5.1 Gagging

Gag reflex is a somatic response in which the body tries to abolish foreign bodies from the oral cavity by muscle contraction at the base of the tongue and the pharyngeal wall. Unstable or poorly retained RPDs, increased occlusal vertical dimension, overextension of the mandibular RPDs in the retromylohyoid space, and the overextended or too thick borders of the maxillary RPDs in the posterior regions can intrude the "trigger zones" and produce gagging. Gagging may usually be observed as a problem of the first-time RPD users and mostly disappears after using the prosthesis for several days. However, patients with severe gagging problems present big difficulties in using the RPDs. Therefore, the RPD design and denture borders should be fabricated with caution taking into consideration the abovementioned factors. The patient and the RPD should be examined thoroughly to find the reason of gagging. Unstable or poorly retained RPDs may be relined or rebased; clasps or precision attachments may be activated or changed, or the RPD may be remade if these are not sufficient enough to maintain adequate retention. To correct the problem of overextensions, the posterior lingual and palatal borders should be shortened and thinned. Correction of the increased occlusal vertical dimension requires reestablishing of the appropriate occlusal vertical dimension and removing and rearranging the artificial teeth of the RPDs. Poor adaptation of the maxillary RPDs to the tissues because of faulty impressions may also induce gagging. If the denture base is acrylic, relining may be the solution of this problem, but if the denture base is metal like most of the cases, the RPD should be remade. Placement of posterior denture teeth lingually may also restrict the tongue space and induce gagging. This can be corrected after removing and rearranging the artificial teeth in correct positions. Alternative treatment options such as hypnosis may also be applied to the patients with stubborn gagging problems.

19.5.2 Eating or Chewing Difficulties

Patients usually report chewing or eating problems before prosthodontic treatment. It should be underlined that these problems decrease rapidly after treated with fixed partial dentures but slowly after RPD treatment due to an adaptation period for the new prosthesis. Moreover, it has been shown that

RPD treatment improves the ability to reduce the bolus particle size but is not able to fully restore the masticatory function especially if it is a distal extension one. However, it has been indicated that perceived chewing ability is an important component of perceived oral health, and therefore these problems should be taken into account seriously. Patients should be advised not to eat tough and sticky food during the early period of adjustment. The occlusal surfaces of the artificial teeth should be examined with an articulating paper, and the occlusal prematurities should be eliminated or the artificial teeth of one or both sides should be reset where an occlusal adjustment is not adequate to overcome occlusal problems, or if some artificial teeth lack occluding the opposing arch. Difficulties may also be related to retention, stability, or vertical dimension. These factors should also be evaluated and corrected if necessary.

19.5.3 Phonetic Problems

Unlike complete dentures, RPDs usually do not generate speech difficulties. However, the location of the anterior teeth especially on a maxillary RPD should be correct in order to allow the tongue and other articulators to work accurately. Also, changes in the contour of the anterior palate and occlusal vertical dimension may show phonetic difficulties. Speech problems are usually seen in the first few days after the insertion of the RPDs especially when the patient is a first-time denture user. It has been shown that most of the patients with these problems show remarkable improvements after 1 week of use. If no improvement is achieved, alterations in the RPD design or tooth arrangement should be considered. Additionally, it should be noted that since degenerative changes in auditory abilities exhibit difficulties to adapt to new prosthesis in older patients, adaptation is usually much easier to achieve in younger patients.

19.5.4 Tongue or Cheek Biting

Tongue, cheek, or lip biting is a common complaint among patients receiving prosthodontic treatment. Patients bite their cheeks mostly because of the inadequate occluding posterior teeth overlap. With the use of monoplane posterior artificial teeth, this problem is seen more often because the teeth are arranged with no horizontal overlap. The cheeks are trapped between the occluding surfaces of the posterior artificial teeth and painful ulcerations may be seen (Fig. 19.11). To overcome the problem of insufficient overlap, the posterior teeth might be gently rounded and reduced in size buccally or all the posterior teeth may be reduced buccally to move away from the soft tissues. However, it should be remembered that reducing the artificial teeth size may reduce the chewing ability of the patients. In those circumstances, the artificial teeth should be changed and rearranged. Cheek biting may be seen in patients who have lost their posterior teeth a long time ago and have never used RPDs. In this situation, the buccinator muscle drops down to the space between the edentulous residual ridge crests. After an adaptation period, the size of the muscle turns back to original, and this complaint is resolved most of the time. Additionally, if the interocclusal space between the posterior denture bases of maxillary and mandibular RPDs is too small, the patient may bite his/her cheek. Grinding the acrylic bases to lengthen the space is the only solution in those situations.

Fig. 19.11 The cheeks may be trapped between the occluding surfaces of the posterior artificial teeth, and painful ulcerations may be seen in patients wearing RPDs with inadequate posterior teeth overlap

Tongue biting may be seen if the artificial teeth have been arranged too lingually or the mandibular posterior teeth have been missing for a long time and the tongue is broadened. The lingual cusps of the mandibular artificial teeth should be broadened to resolve the problem. In the case of long-time missing posterior teeth scenarios, the patients stop biting their tongue after the tongue turns to its normal size if the teeth were set in correct position.

Lip biting may be seen with the presence of wrong anterior teeth relations and is usually resolved by reshaping the labial surface of mandibular canine teeth.

19.5.5 Food Impaction or Collection on the RPD Borders

Food impaction happens usually when the acrylic denture base is not well adapted to the abutments (Fig. 19.12). The reason is usually starting the treatment without restoring the abutment teeth. Therefore, restarting the treatment with proper planning including restoring the abutments rather than relining is more appropriate in these situations. However, if the food trap is due to an insufficiently extended denture base, the solution may be a relining. Food collection on the borders may occur in the case of poorly contoured or not well-polished acrylic surfaces or if the patient has a reduced salivary flow. Appropriately contouring and polishing the surfaces will easily solve the problem. If a reduced salivary flow is present, medications increasing the flow rate may be prescribed or chewing gums and fluids stimulating the flow may be recommended to the patients. Some RPD designs such as lingual bar with cingulum bar and designs requiring deep reliefs because of anatomic restrictions or insufficient beading may also cause food impaction, which may only be corrected by refabricating the RPDs with a more appropriate planning.

Fig. 19.12 When the acrylic denture base of the RPD is not well adapted to the abutment tooth, food impaction is unavoidable

19.6 Esthetic Problems

RPDs replacing the anterior teeth may cause esthetic problems. These problems may be related to several factors. But before explaining these factors, it is very important to describe the esthetic zone and its effect on RPD treatment options.

19.6.1 Esthetic Zone

Esthetic zone is the observed teeth and soft tissues when a patient makes a usual smile or laugh. However, Preston describes the esthetic zone as the place wherever the patient thinks it is, meaning that even if the patient does not show metal while laughing, he/she still may believe that it is seen. Therefore, it is essential to describe the esthetic zone to the patients before the treatment because they might not want to receive any metal on the facial surfaces even if it is not in the esthetic zone. The open smiles of patients were divided into three categories as high smile, average smile, and low smile in a former study. It is easier to mask the metal components in a low smile which displays less than 75 % of the anterior teeth; but every component is visible in a high smile that shows all the anterior teeth and a contiguous band of gingiva. Therefore, it is much better to select alternative designs in these circumstances such as precision attachments or rotational path designs (see Chaps. 12 and 16) which do not show the metal components. However, it should be underlined that most of the patients have average smile in which the cervical to incisal length of the maxillary anterior teeth is displayed to either the first or second premolar. Therefore, it is very important to eliminate the metal components until the maxillary premolars for the majority of individuals. Additionally, some precautions should be considered about the maxillary denture base contours. The anterior flange should not be thick and extend to the reflection of the mucolabial fold to prevent the horizontal border of the flange from being visible during smiling.

Mandibular anterior teeth should be taken into account if they are to be replaced with an RPD. Most of the patients show 50 % of the mandibular anterior teeth and less than 50 % of the buccal surfaces of the premolars in the esthetic zone; similarly, the occlusal surfaces of the premolars are usually displayed.

Most of the esthetic problems of RPDs are due to display of the metal components such as clasp assemblies or frameworks in the esthetic zone. These problems may be solved mostly with replacement dentures which follow the rules of the esthetic zone. Therefore, it is very important to plan the RPD before the treatment according to the esthetic zone of the patient. Additionally, the esthetic problems may be due to inappropriate axial inclination of the artificial tooth positions, discoloration or abrasion of the acrylic teeth, and too low or too high occlusal plane. These problems may be solved by replacing the artificial teeth with new ones.

19.7 Compromised Periodontal Health and Mucosal Lesions

The existence of the RPD in the oral cavity affects the microbial ecosystem onto both the remaining teeth and the oral mucosa because of plaque accumulation and hygienic maintenance. Although it has been publicized that if precise hygienic techniques and regular recalls are being applied, RPDs may not cause an increase of plaque accumulation; the majority of the studies focusing on this subject reported increased susceptibility to plaque accumulation with the use of RPDs. The proliferation of *Spirochetes* and *Fusobacteria* upsurges with the presence of RPDs.

While a rise of gingival inflammation at the marginal gingiva of the teeth in contact with the components of the RPD has been reported in a number of studies, others failed to find any difference at the gingival margin of the teeth that are in contact or not with the RPDs. Most of the studies showed an increase in the depth of the pockets in RPD users. However, there are also investigations pointing out no changes. Bergman and Ericson showed that 3 years after RPD treatment, periodontal parameters were much better in patients who paid an annual check to a dentist as compared with those who did not. It was presented in a comparative study that both the RPD users and nonusers showed an increase in periodontal parameters after 8 or 9 years showing that this increase should not be related directly to RPD usage. Nevertheless, there still seems to be a controversy regarding the effect of RPDs on gingival inflammation or pocket depth in the dental literature. It may be concluded that good oral hygiene, proper RPD design, and most prominently regular recalls for RPD users are essential for controlling and preventing the occurrence of periodontal diseases.

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20 Maintenance

Onur Geckili

20.1 Definitions

Border molding The shaping of the border areas of an impression material by functional or manual manipulation of the soft tissue adjacent to the borders to duplicate the contour and size of the vestibule.

Braze To join with a nonferrous alloy that melts at a lower temperature than that of the metals being joined.

Elastomeric impression material Group of flexible chemical polymers, which are either chemically or physically cross-linked. Generally, they can be easily stretched and can rapidly recover their original dimensions when applied stresses are released.

Flask A metal case or tube used in investing procedures.

Flasking The process of investing the cast and a wax replica of the desired form in a flask preparatory to molding the restorative material into the desired product.

Intaglio surface The portion of the denture or other restoration surface that has its contour determined by the impression; the interior or reversal surface of an object.

Irreversible hydrocolloid A hydrocolloid consisting of a sol of alginic acid having a physical state that is changed by an irreversible chemical reaction forming insoluble calcium alginate.

Laser welding The joining of metal components through the use of heat generated with a laser beam.

Modeling plastic impression compound A thermoplastic dental impression material composed of wax, rosin, resins, and colorants.

Polishing The act or process of making a denture or casting smooth and glossy.

Polyether An elastomeric impression material of ethylene oxide and tetra-hydrofluro copolymers that polymerize under the influence of an aromatic ester.

Polysulfide An elastomeric impression material of polysulfide polymer (mercaptan) that cross-links under the influence of oxidizing agents such as lead peroxide.

Polyvinyl siloxane An addition reaction silicone elastomeric impression material of silicone polymers having terminal vinyl groups that cross-link with silanes on activation by a platinum or palladium salt catalyst.

Rebase The laboratory process of replacing the entire denture base material on an existing prosthesis.

Reline The procedures used to resurface the tissue side of a removable dental prosthesis with new base material, thus producing an accurate adaptation to the denture foundation area.

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Separating medium A coating applied to a surface and serving to prevent a second surface from adhering to the first.

Solder To unite, bring into, or restore to a firm union; the act of uniting two pieces of metal by the proper alloy of metals.

Warp Torsional change of shape or outline; to turn or twist out of shape.

Wrought 1: worked into shape; formed 2: worked into shape by tools; hammered.

Successful treatment with RPDs requires periodic evaluations and proper maintenance in the follow-up appointments. Especially distal extension RPDs have a special need for maintenance, mainly relining or rebasing because of the continuing alveolar bone resorption. If a distal extension RPD loses the support of soft tissues and begins to move, damage to the abutments and soft tissues are unavoidable. Therefore, a distal extension RPD should be relined periodically to maintain its close adaptation to the underlying soft tissues and to avoid causing subsequent trauma to the oral cavity.

20.2 Relining and Rebasing

In case of loss of the supporting tissues, the most convenient treatment is the relining of the RPD. Rebasing is needed when the denture base has some fractures, cracks, or has become irreparably discolored. It is very important to differentiate the meanings of relining and rebasing to avoid confusion as they are frequently mixed up. In both situations, a new impression is necessary. However, it is also possible to complete the relining in a chairside intraoral technique, which is not possible in the rebasing procedures. To determine the need for relining or rebasing an RPD, the following evaluations may be undertaken:

1. Place a thin portion of irreversible hydrocolloid or elastomeric impression material to the intaglio surface of the RPD base; seat the RPD in the mouth and wait until the impression material sets. Remove the RPD and inspect for the thickness of the impression material. If it is more than 2 mm thick, make a reline (Fig. 20.1).
2. Seat the RPD in the mouth and apply a seating pressure on the most posterior part of the RPD and inspect the indirect retainers. If the indirect retainers lift more than 2 mm, make a reline (Fig. 20.2).
3. Instruct the patient to close the mouth in centric occlusion and inspect for the posterior contacts of the RPDs. If a loss of occlusal contacts on the posterior teeth is inspected (Fig. 20.3), place a wax on the occluding surfaces and instruct the patient to close. Inspect the wax, and if the occlusal contact between artificial dentition is lacking, make a reline together with an occlusal correction.
4. If there exists a stubborn ulceration, inflammation, or hypertrophy on the soft tissues underlying the RPDs (Fig. 20.4), apply a tissue conditioning material after relieving the denture base surfaces touching the irritated areas and make a reline. The patient uses the RPD with the tissue conditioner for at least 24 h. The procedure will be discussed in the following sections.

Relining procedures may be accomplished by two major techniques:

1. Direct (chairside) technique
2. Indirect technique

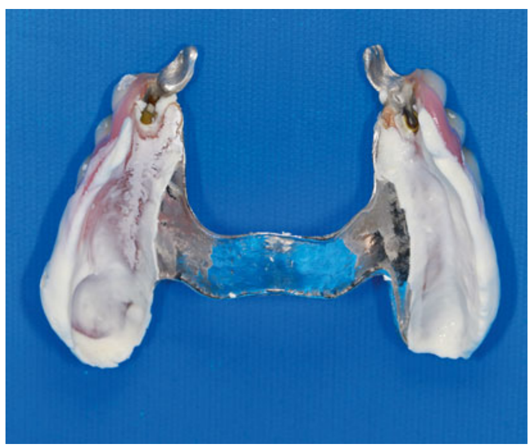

Fig. 20.1 A thin portion of irreversible hydrocolloid is placed to the intaglio surface of the RPD base to see if the RPD has to be relined. In the right extension base, the thickness of the impression material is more than 2 mm presenting the need of a reline whereas the impression material in the left extension base is less than 2 mm presenting no need for relining

Fig. 20.2 RPD is seated and a pressure is applied on the most posterior parts. The indirect retainers lift more than 2 mm, pointing out the need of relining

Fig. 20.3 If the occlusal contact between artificial dentition is lacking, a reline together with an occlusal correction is essential

Four primary criteria for an RPD reline can be listed as:

1. Good chemical bond
2. Satisfactory strength
3. No warping or dimensional change in the prosthesis
4. Speed of the procedure

Despite the time and cost savings of the direct technique, the advantage of the indirect technique is a harder, denser, and more completely cured resin reline compared with direct-reline materials. The materials used for direct-reline procedures are more porous and flexible and less color stable. Additionally,

Fig. 20.4 A stubborn ulceration exists on the labial vestibule. The RPD base should be shortened and a tissue conditioner should be applied afterward to promote healing

although both the heat-cured PMMA used in the indirect technique and the direct-reline materials contain some residual monomer, which may be cytotoxic to particular patients, direct-reline materials comprise a greater risk because of less polymerization. In general, the indirect method has been preferred because of the above-mentioned advantages, but no long-term studies have compared the outcomes of the two methods.

Before starting the relining procedures, the oral mucosa should be returned to an acceptable state of health that may require a period of function without the RPD or using the RPD with a tissue conditioner after relief of the RPD in the effected regions.

20.2.1 Relining Tooth-Supported RPDs

The need of relining the tooth-supported RPDs is not common because the tissue changes that arise underneath the denture bases do not distress the support of the RPDs. Since the abutments rather than the residual ridges absorb the occlusal loads, tooth-supported RPDs have the minimum amount of residual ridge resorption. Relining procedures are performed only for hygienic or esthetic reasons. It is much more practical to use an intraoral chairside technique when a tooth-supported RPD is to be relined. Because making an impression requires that the RPD be flasked and processed, the occlusal vertical dimension may be increased and the RPD may be distorted during laboratory procedures. It is not feasible to take these risks for such an easy procedure if the RPD has not to be rebased.

20.2.2 Relining Distal Extension RPDs

Distal extension RPDs require correction by relining or rebasing much more often than tooth-supported RPDs because the majority of the support is from the underlying soft tissues and residual ridges and more occlusal loads are directed to the residual ridges through the prosthesis. The patient should be informed that a distal extension RPD requires periodic examination and relining due to maintaining the health of the abutment teeth and the residual ridges before the treatment. This information has an important role in defending the rights of the clinician to charge the patient in periodic visits.

20.2.3 Step-by-Step Procedures for Direct or Indirect Relining

No matter what technique is being used, sufficient amount of denture base (minimum 1 mm) should be relieved from the intaglio surface of the RPD to be relined. The space provided with relieving prevents the impression material to apply inappropriate pressure to the underlying tissues and potential contaminants to warrant a suitable bonding surface. Additionally, the undercuts should be removed to evade fracture of the final cast both during the separation of the impression and the processing procedures.

20.2.3.1 Direct Relining

The procedure for directly relining an RPD is as follows:

1. Apply a separating medium to the occlusal surfaces of the remaining teeth and polished surfaces of the RPD which are not to be modified in order to avoid new resin from adhering to these surfaces and teeth.

Fig. 20.5 A surface primer is applied with a small brush to enhance bonding strength of the resin reline material

2. Apply a surface primer which is mostly supplied with the reline product or some of the reline resin monomer if the primer is not supplied, with a small brush to enhance bonding strength of the resin reline material (Fig. 20.5).
3. Mix the powder and liquid of the resin reline material in a suitable mixing container and apply to the intaglio surface of the RPD and the borders to be relined after the material begins to set but in an easily flowable stage. If the material is in a cartridge, insert the cartridge in the dispensing gun, mount a mixing tip, and apply the material into the RPD base (Fig. 20.6).
4. Place the RPD in the mouth ensuring that all the rests are in their proper places and instruct the patient to close slightly into maximal intercuspal position. It is very important to avoid flowing of the material over the occlusal surfaces in order not to change the established vertical dimension of occlusion.
5. Instruct the patient to open the mouth and manipulate the cheeks and the lips for border molding. If a mandibular RPD is to be relined, instruct the patient to move the tongue to the cheeks, lips, and to the anterior teeth for shaping the lingual borders. Be sure that the RPD is not displaced during border molding. If you are not sure, put a finger pressure on the rests while border molding is in progress.

Fig. 20.6 The resin reline material is applied to the intaglio surface of the RPD

Fig. 20.7 When the resin reline material starts to be elastic, excess material is removed with a scalpel

6. Remove the RPD from the mouth when the material starts to be elastic, trim away the excess material with a scissors or scalpel (Fig. 20.7), and return the RPD into the patient's mouth afterward.
7. Instruct the patient to occlude the teeth slightly to check occlusal vertical dimension and then open his/her mouth to hold the framework against the abutments until the material totally sets. If the patient is asked to close the mouth and occlude until the material sets, the patients may rotate the distal extension base and over-compress the soft tissues if he/she does not close exactly into the desired occlusion. Therefore, it is much safer to finish the setting of the resin material with the aid of the clinician and with the mouth open.

Fig. 20.8 To eliminate any tissue damage that could have resulted from the exothermic heat or prolonged contact of the tissue with unreacted monomer, the RPD is immersed in a container of 45 °C–50 °C water for at least 15 min to polymerize

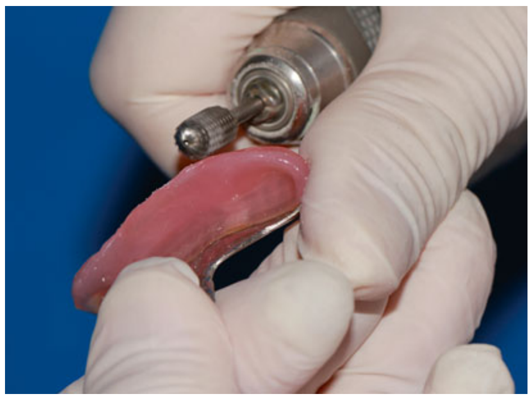

Fig. 20.9 A neat finish line is prepared between the reline material and acrylic base with the aid of appropriate burs

8. Remove the RPD from the mouth, rinse it in water, and examine the relined surfaces. To eliminate any tissue damage that could have resulted from the exothermic heat or prolonged contact of the tissue with unreacted monomer, put the RPD in a container of 45 °C–50 °C water for at least 15 min (Fig. 20.8) or in a pressure pot for 20–30 min to polymerize.
9. After curing, trim the excess parts with appropriate burs and a rotary instrument to provide a neat finish line between the reline material and acrylic base (Fig. 20.9). If the material is a soft liner, use cross-cut steel burs for bulk reduction.

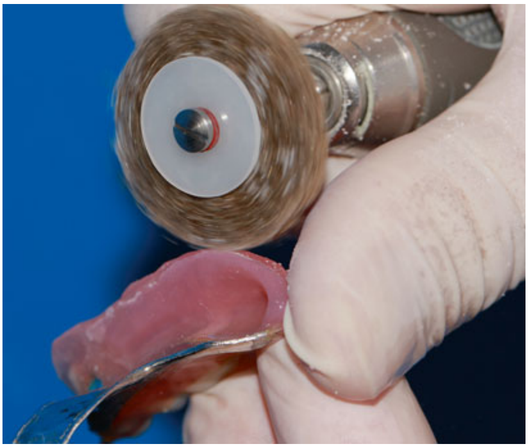

Fig. 20.10 Polishing disks are used for finishing

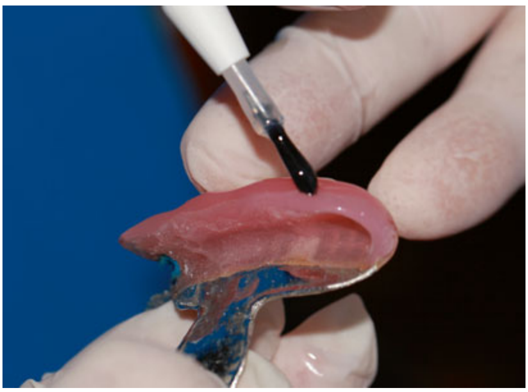

Fig. 20.11 If the material is a soft liner, a thin layer of silicone sealant is applied with a brush within 90 s

10. Finish with the polishing disks supplied with the material (Fig. 20.10) and if the material is a soft liner, apply a thin layer of silicone sealant with a brush within 90 s (Fig. 20.11) and return the relined RPD into the mouth.
11. Check the occlusion and adjust if any change has occurred.
12. Check the borders and the intaglio surface with the aid of a pressure-indicating paste to ensure they are not over-extended and deliver the relined RPD to the patient.

20.2.3.2 Indirect Relining

For a successful indirect relining, it is vital to select the appropriate impression material. The impression material should not extend beyond the support of the denture base. The choice of impression material should be determined by the characteristics of the tissues. Zinc oxide–eugenol impression material is indicated for most of the tissue types but strongly recommended if mobile tissues are present on the alveolar crest. If relining is to be performed on dense, firm tissues, polysulfide rubber bases, polyether, polyvinylsiloxane, and mouth-temperature waxes may similarly be used with confidence.

For indirect relining, especially if the mucosal tissues are damaged, tissue-conditioning materials may be applied to the extension bases (Fig. 20.12) and after setting, the RPD is removed and inspected. The excess borders are removed using a scalpel (Fig. 20.13) and the patient is released to use the RPD for 24 h and recalled. On the recall session, the RPD is evaluated; the excess parts are trimmed or the short borders are completed with a newly mixed

Fig. 20.12 Tissue-conditioning materials may be applied to the extension bases as a reline material

Fig. 20.13 After setting, the RPD is removed and inspected and the excess borders are removed using a scalpel

Fig. 20.14 When the patient has no complaints through the RPD with the tissue conditioning material, it may be sent to the laboratory directly for an indirect reline

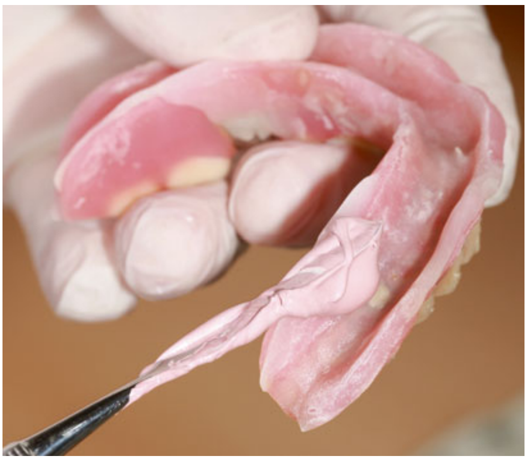

Fig. 20.15 In order to achieve better accuracy, it is preferable to apply a free-flowing zinc oxide–eugenol impression material for an additional reline impression onto the tissue conditioning material

tissue-conditioning material and the patient is released again to use the RPD for a few more days. After the clinician is confident and the patient has no complaints with the RPD, it may be sent to the laboratory straight for an indirect reline (Fig. 20.14). However, in order to achieve better accuracy, it is advised to apply a free-flowing zinc oxide–eugenol impression material for an additional reline impression onto the tissue conditioning material (Fig. 20.15). After setting, the RPD is removed and sent to the laboratory directly for processing or an over-impression may be made using an irreversible hydrocolloid (Fig. 20.16). After the processing procedures carried out in the laboratory, the relined RPD is delivered to the patient.

Fig. 20.16 Additionally an over-impression may be made using an irreversible hydrocolloid

The procedure for indirect relining an RPD is as follows:

1. If border molding is necessary, use a low-fusing modeling plastic impression compound: green or gray stick, for shaping the peripheral extensions step by step or a polyether impression material in one step. If a mandibular distal extension RPD is to be relined, perform border molding from the anterior extent of the buccal flange to the most posterior extent of the RPD and on the lingual and distolingual flanges. If the reline is needed for under-extended borders, border molding may be completed only on these surfaces to extend the missing parts (Fig. 20.17). Border molding may also be made in one step using a polyether impression material. In that case, an adhesive should be placed to the borders of the RPD and polyether is syringed around the borders and border molding is carried out afterward.
2. Make the final impression with zinc oxide–eugenol impression material if border molding has been done with modeling sticks. If border molding is not necessary, step 1 may be eliminated and the impression may be made with one of the above-mentioned impression materials.
3. Make sure that all the rests are in their designed position on the abutment teeth and maintained in this position until the impression material sets (Fig. 20.18). An open mouth impression technique is advised for an easy observation of placement of the rests into their rest seats (Fig. 20.18).

Fig. 20.17 Border molding may be accomplished to lengthen the under-extended borders during relining

Fig. 20.18 An open mouth impression technique is advised for an easy observation of placement of the rests into their rest seats

4. Remove the impression and examine for precision (Fig. 20.19). Small defects may be corrected using a mouth temperature wax. If large defects are present, the impression should be repeated.
5. Return the impression to the patient's mouth and inspect for accurate placement of the rests.
6. Make an over-impression with alginate impression material to obtain a complete arch cast (Fig. 20.20). (The impression may be sent directly to the laboratory without making this over-impression.)

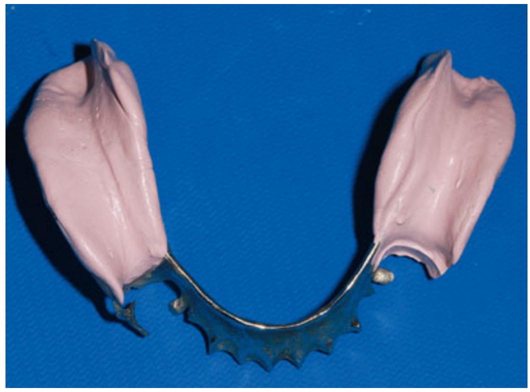

Fig. 20.19 The impression is removed and examined

Fig. 20.20 An over-impression may be made to obtain a complete arch cast

7. Pour the impression with Type III dental stone to make a definitive cast, but do not separate it from the cast after setting.
8. Close the spaces with wax, trim the teeth, and remove the undercut areas to prepare the impression and the cast assembly for flasking.
9. Pour Type II dental stone into the flask; position the cast and allow the stone to set completely (Fig. 20.21).
10. Place the flask in boiling water for 5 min; remove the wax and border molding material and the impression from the cast (polyether and polyvinylsiloxane impression materials may be separated immediately after the dental stone is set without the necessity of heat). Make sure that the RPD is completely cleared from all the impression material and the wax residue.

Fig. 20.21 Type II dental stone is poured into the flask; the cast is positioned and the flask is immersed in boiling water for 5 min to remove the wax and the impression from the cast

Fig. 20.22 Heat polymerizing acrylic resin is applied in the flask and polymerized using an appropriate method

11. Mix and place heat polymerizing acrylic resin in the flask (Fig. 20.22), close the flask, and polymerize the resin using an appropriate method.
12. Shape and polish the relined RPD (Fig. 20.23) using conventional techniques and deliver the RPD to the patient.

20.3 Repairs

The need for repairs to RPDs may arise after using for some time or sometimes instantly following the delivery of the prosthesis. Repairs are usually completed in the laboratory and the

Fig. 20.23 The relined RPD is shaped and polished after removing from the flask and delivered to the patient

patients are left without their prosthesis for several days. This is generally not well tolerated by most patients. Therefore, the clinician should be able to repair the RPD immediately if he/she could instead of sending it to the laboratory. RPD repair types are as follows:

1. Denture base repairs
2. Repair of major or minor connectors
3. Repair of the rests or direct retainers
4. Repair of fractured or lost artificial teeth
5. Loss of a natural tooth necessitating its replacement
6. Other repairs

20.3.1 Denture Base Repairs

A section of the denture base may be lost or fractured from the rest of the RPD usually because of careless handling by the patient. If the fractured denture base is lost or cannot be accurately positioned on the fracture site because of deterioration, a reline impression is made with the use of modeling compound to complete the fractured site. After the impression is poured to fabricate a master cast, the fractured segment is repaired with either autopolymerizing or heat-cured acrylic resin. However, it should be remembered that if the fractured segment is too large it might not be possible to reshape the tissue contours with the modeling compound and the RPD has to be reconstructed.

If the fractured segment is available and can be accurately positioned on the fractured site, a simple in-office procedure is usually adequate for the repair. The fractured pieces are joined with sticky wax and dental stone is poured against the tissue side of the denture base to produce a master cast. After setting, the RPD is removed from the cast, the fractured segments are separated, and the fracture line is opened for about 1–2 mm. A separating medium is applied to the cast; the segments are returned to the master cast and accurately positioned. Autopolymerizing acrylic resin is applied to the prepared space until the space is slightly overfilled. The resin may be left for polymerizing or the cast and RPD assembly may be placed in a pressure cooker or pressure pot for 20–30 min for less internal porosity. After polymerization, the base is trimmed, polished, and delivered to the patient.

20.3.2 Repair of Major or Minor Connectors

Major or minor connectors usually do not break because they have adequate bulk of metal. A major connector may weaken due to frequent adjustments to overcome adaptation or tissue impingement problems. Additionally major connectors which are not rigid and indicated in only some particular situations like Kennedy bar may weaken after some time; and the weakened parts cannot tolerate intraoral stresses and may break (Fig. 20.24). Misuse of the patients may also be a reason of the distortion of the major or minor connectors. Usually clinicians choose the option to reconstruct the RPDs when the major connectors are broken. However, there are methods to repair them at least for the interim use of the patients.

20.3.2.1 Soldering or Brazing

As stated by the American Welding Society, if the joining process is below 425° C, the operation is called soldering and if the temperature is above 425° C, it is called brazing. The process of bracing or torch soldering may be used for the repair of an RPD framework without acrylic resin base. A minimum space of 0.2–0.3 up to 0.5 mm should be obtained between the fractured segments with the use of aluminum oxide disks or fine diamond burs. An oxygen-propane torch is used for heating the segments to be joined until they are red hot, and then melted solder alloy with or without the same metal is flowed into the joint area. Once the soldering operation has initiated, it is important not to remove the flame in order not to cause cooling to overcome oxidation. The investment is left to cool slowly and then the framework is cleaned, finished, and polished with the aid of appropriate instruments and burs. This method is well known by the laboratories and cheap but it has some disadvantages as follows:

(a) Oxidation of the joined segments
(b) Structural defects and failure of the finished framework due to porosity and overheating
(c) Cannot be used to repair an RPD having a resin denture base or artificial teeth

Fig. 20.24 Kennedy bar may weaken after some time, and the weakened parts cannot tolerate intraoral stresses and may break

More recently developed electric soldering involves tungsten inert gas (TIG) welding and plasma arc welding (PAW). Both systems use a torch with a tungsten electrode and a shielding gas source. The advantage of electric soldering is the ability to repair an RPD without damaging the acrylic resin base. The acrylic resin base

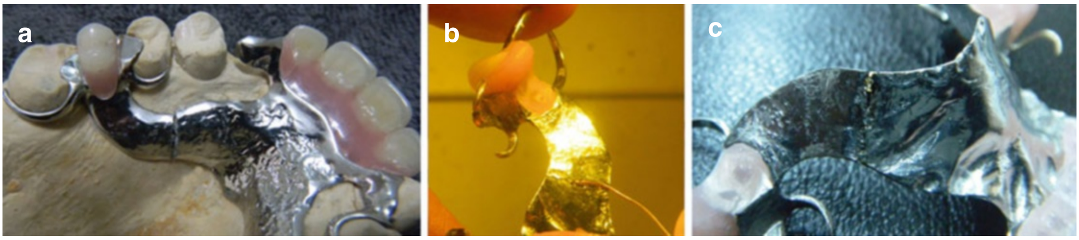

Fig. 20.25 An impression is made with the broken RPD framework and a cast is obtained (**a**). After the components are airborne-particle abraded, they are rigidly stabilized by tacking with a laser-welding machine, and after stabilization welding with a parent Co-Cr wire is completed (**b**). After laser welding (**c**), the framework is finished and polished

should be protected with a wet casting ring liner during the electric soldering procedure. The main disadvantage is the presence of porosities in the soldered region because of the argon gas.

20.3.2.2 Laser Welding

Laser welding has been developed recently and successfully used in the repair of RPD framework fractures (Fig. 20.25) or clasp repair procedures and has been suggested as the best welding technique for dissimilar metals.

The technique ensures a high-intensity, concentrated light beam to reach the metal surface. As the metal absorbs its energy, it converts it into heat that takes the metal to its melting point. Before starting the laser welding procedure, the fractured segments and adjacent areas should be sandblasted to reduce laser beam reflection.

The advantages of the laser welding technique include higher tensile strength of the joints, permission to weld near acrylic or ceramic surfaces and less time. However, the equipment is very expensive, porosities in the region of the union may occur, and the two joining segment surfaces must have a full contact, which is very hard to achieve in some situations.

20.3.2.3 Repair with Splinting Using Metal Conditioners

It is also possible to repair a lingual plate with a cast splint and metal adhesive system. After the fractured segments are accurately positioned and a dental stone model is obtained, a groove is prepared on the lingual plate reaching the fractured denture base. A wax pattern is prepared duplicating the prepared groove and cast with a silver palladium copper gold alloy. The lingual plate is air abraded and a metal conditioner is applied to the surface. The splint is positioned on the groove and attached using an adhesive luting cement (Fig. 20.26). It should be underlined that this method may only be used for interim use until a new RPD is fabricated.

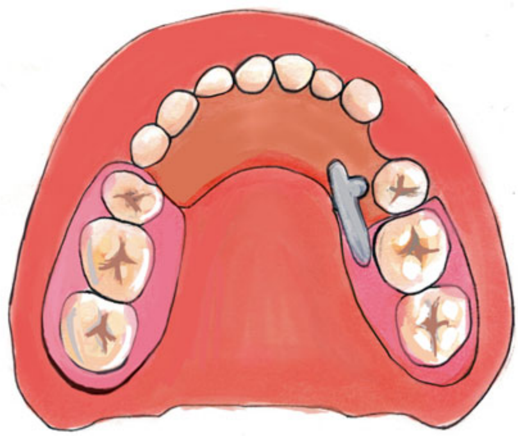

Fig. 20.26 A broken lingual plate may be repaired with a cast splint and metal adhesive system for an interim use

20.3.3 Repair of the Rests or Direct Retainers

Occlusal rests may fracture as a consequence of insufficient rest seat preparations. The rests, which have to be made too thin or have been weakened because of occlusal adjustments, may fracture. It is much better to reconstruct the RPD with appropriate seat preparations, but the rests

Fig. 20.27 If the occlusal rests are fractured, an impression is made with the RPDs after appropriate seat preparations have been made. The prepared rest seats are filled with impression material and the provided spaces may be observed and inspected

may also be repaired by soldering or laser welding. However, in order not to cause additional fractures the rest seats should be prepared and an impression with the RPD having fractured rests should be made. After the completed impression is poured to fabricate a master cast, the prepared rest seats are filled with impression material and the provided space may easily be observed and inspected (Fig. 20.27).

The most common broken component of an RPD is the clasp arm because it emerges freely from the RPD. Before repairing an RPD with a broken clasp arm, the possible reasons for the breakage should be evaluated in order not to cause repeated damages. Following are the possible reasons for broken clasp arms.

1. *Deep undercut*: This type of breakage is a safe one and it prevents loosening of the abutment. Undercut should be reduced before repair (see Chap. 5).
2. *Accidental dropping by the patient*: RPD users are mostly elder and may have dropped the RPDs.
3. *Mechanical failure of the clasp arm*: If the metal thickness at the fracture site is less than 1.2 mm, immediate repair cannot be a solution. Proper mouth preparation in order to thicken the metal surface before repair is essential. Additionally, the clasp arms may have voids or pores which have occurred during investing and this may affect fatigue resistance of clasps subjected to repetitive loads during insertion and removal of the RPD. This may trigger mechanical failure of the clasp arms.
4. *Frequent adjustments made by the clinician*: Excessive manipulation of the clasp arm both during initial adaptation and during the follow-up visits may weaken and break the clasp arm. It is very important not to adjust the clasp arm beyond the elastic limit of the metal.

The broken clasp arms can be repaired using the following methods.

20.3.3.1 Repair with a Wrought Wire Clasp

This method is the most common one because it may be completed in the dental office without sending the RPD to the laboratory. It is a cost effective and faster method both for the patient and the clinician. The procedure is as follows step-by-step:

1. Seat the RPD with the broken clasp in the mouth and check for fit and position (Fig. 20.28).
2. Make an irreversible hydrocolloid impression with the RPD and immediately pour with dental stone (Fig. 20.29). If the clasp is broken during the initial visit, a separating medium should be used before pouring the impression.
3. Remove the RPD from the cast and eliminate the fractured part of the clasp using an appropriate bur and create a space or groove in the lingual flange of the denture base just below the artificial teeth for the mechanical retention of the wrought wire.
4. Shape and contour an 18 gauge wrought wire; adapt to the abutment and secure in place with a sticky wax on the cast and seat the RPD over the wire after preparing space on the acrylic (Fig. 20.30).
5. Apply the autopolymerizing resin to the prepared place and final cure in a temperature and pressure controlled unit in warm water (about 50–60° C) for 30 min at 30 psi.

Fig. 20.28 RPD with the broken clasp is seated and checked for fit and position

Fig. 20.29 An impression is made with the RPD and immediately poured with dental stone

6. Finish and polish with appropriate instruments (Fig. 20.31), check intraorally (Fig. 20.32), and deliver the RPD to the patient.

20.3.3.2 Repair with Soldering a Wrought Wire Clasp

The broken clasp arms may also be repaired using electric soldering or laser welding techniques. A precious metal high fusing wire should be used and torch soldering is not indicated in order not to overheat and damage the acrylic resin.

Fig. 20.30 RPD is removed from the cast and an 18 gauge wrought wire is shaped and adapted to the abutment and secured in place using sticky wax

Fig. 20.31 Acrylic resin is applied to the prepared place, and after polymerization, the RPD is finished and polished with appropriate instruments

20.3.3.3 Repair with a Cast Clasp

A dental stone cast with the RPD is obtained and after the RPD is removed from the cast a desired type of cast clasp is fabricated in this method. The cast clasp is attached to the existing RPD using cold curing acrylic resin afterward (Fig. 20.33).

20.3.3.4 Chairside Repair with a Cast Clasp

In this method, a groove is prepared in the buccal surface of the RPD where the clasp is broken. This groove should be at least 3–5 mm wide and 2–3 mm deep and 10–15 mm in length with 2 or 3 raised index islands or depressions. An impression is made with the RPD, poured after the RPD is removed from the impression, and the RPD is returned to the patient after covering the prepared space with wax. A sectional refractory model is

Fig. 20.32 The repaired RPD is checked intraorally and delivered to the patient

Fig. 20.33 A cast clasp may be attached to the existing RPD with a broken clasp using a cold curing acrylic resin

prepared from the working area and a clasp with a temporary stabilizing arm is cast (Fig. 20.34). At the second visit, the cast clasp with the stabilizing arm is positioned to the prepared space and attached to the RPD with an autopolymerizing resin. The stabilizing arm is removed with an appropriate bur, and the finished clasp may be prepared and modified as a T, Y, or I bar clasp (Fig. 20.34).

20.3.4 Repair of Fractured or Lost Artificial Teeth

One or more artificial teeth of an RPD may be dislodged, lost, or broken. The dislodgement of an artificial tooth may result from its insufficient bonding to the resin base. This may originate from a separating medium or wax residue left between the artificial teeth and the acrylic resin base during processing of the RPD and may be easily repaired using autopolymerizing acrylic resin if the artificial teeth have not been lost. If any artificial tooth is lost or broken as a consequence of mishandling by the patient, it may be replaced with a new one having the same color and material using an autopolymerizing resin. These procedures can be done without making an

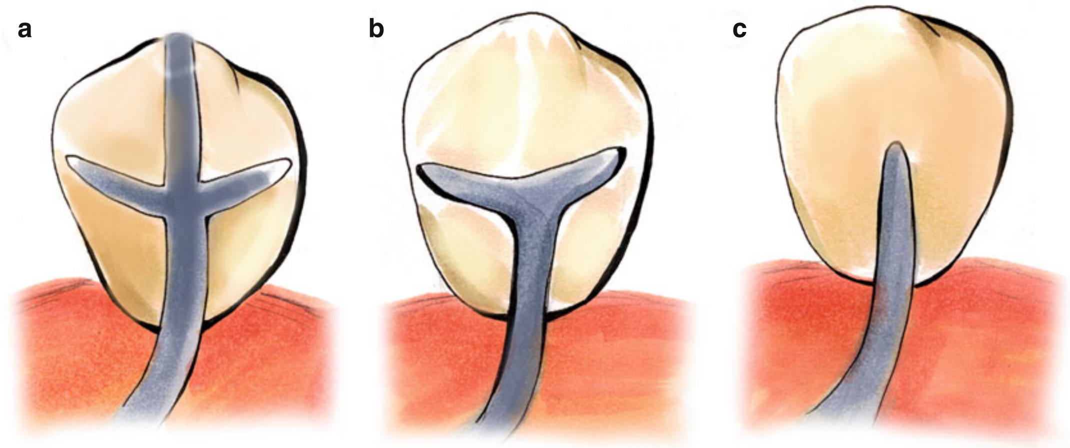

Fig. 20.34 In order to repair an RPD with a broken clasp, a clasp with a temporary stabilizing arm may be cast, fastened to the abutment tooth (**a**), and attached to the RPD with an autopolymerizing resin. After removing the stabilizing arm, the clasp may be prepared as a T, Y, or I bar clasp (**b**, **c**)

impression. However, if the lost or broken artificial tooth is adjacent to one of the abutments, an impression with the RPD is essential before replacement in order to contour the contact area.

20.3.5 Loss of a Natural Tooth Necessitating Its Replacement

If a natural tooth of the patient other than the abutment is extracted, it may easily be replaced by adding an artificial tooth to the RPD if an appropriate major connector has been designed. However if the major connector is a palatal bar, strap, or a lingual bar, it is not possible to replace an anterior lost natural tooth because it is not possible to retain the artificial tooth to the major connector. If the major connector has a suitable design for addition of an artificial tooth like a full or U shaped palatal plate or a lingual plate, an impression is made with the RPD (Fig. 20.35) and poured with dental stone to obtain a cast (Fig. 20.36). A loop or a mesh design framework is cast and soldered to the RPD space requiring the artificial tooth addition (Fig. 20.37). A suitable artificial tooth is shaped and contoured and retained to the existing RPD using autopolymerizing acrylic resin afterward (Fig. 20.38). If the lost natural tooth requires a distal extension denture base to be extended, the subsequent relining of the entire base is essential in order to provide favorable tissue support. If the abutment tooth is extracted, it is still possible to retain an artificial tooth to the above-mentioned RPD designs after an impression with the existing RPD using the next adjacent tooth as an abutment, but this tooth should have a suitable retentive area, proximal guiding plane, and a rest seat. If not, a new restoration should be made to the adjacent tooth to conform these requirements. The existing clasp on the RPD is removed and an artificial tooth is added instead of the natural abutment tooth. A

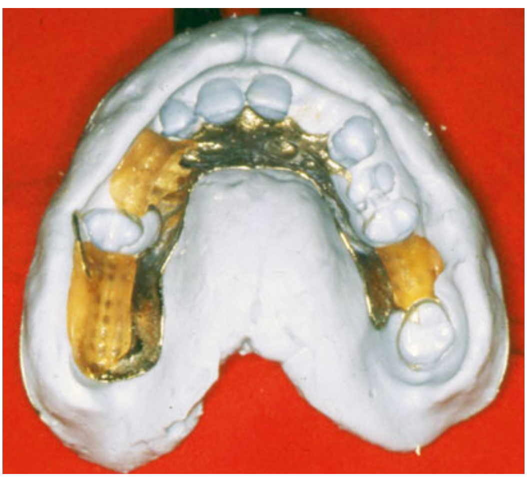

Fig. 20.35 When a natural tooth is extracted, in order to fill the space with an artificial tooth, an impression is made with the RPD in place

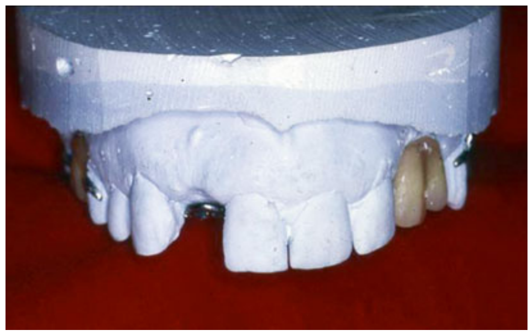

Fig. 20.36 The impression is poured with dental stone to obtain a definitive cast with the RPD

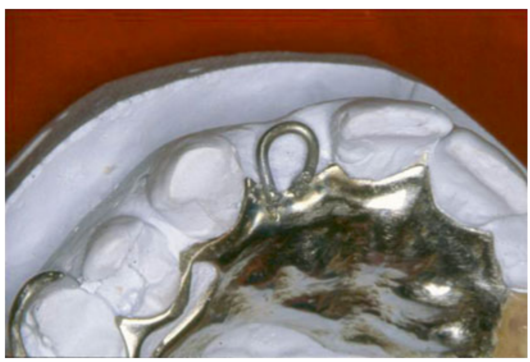

Fig. 20.37 In order to facilitate the retention of the artificial tooth, a loop is cast and soldered to the space where the natural tooth has been extracted. Besides, it is much better to make a finishing line lingually for the acrylic border

Fig. 20.38 An artificial tooth is shaped, contoured, and retained to the existing RPD using autopolymerizing acrylic resin afterward

new clasp assembly is prepared and electrically soldered or laser welded to the RPD, and the PRD is delivered to the patient afterward. Additionally it is possible to add an artificial tooth and a wrought wire clasp retaining the adjacent tooth to the RPD. But this method is indicated just for an interim use because of the absence of a rest and consequent support of the RPD.

20.3.6 Other Repairs

20.3.6.1 Repair of an Abutment

When the abutment tooth is damaged, it is possible to restore the tooth without reconstructing the RPD with the aid of post cores. After an appropriate root canal treatment, the post space is properly prepared and the post core is made with an autopolymerizing acrylic resin (pattern resin). The core should fit the existing crown; therefore the core part should be prepared with caution (Fig. 20.39). The intaglio surface of the crown should be isolated with a separating medium and the core part of the acrylic resin should be poured into the crown. After polymerization, the acrylic post core is separated from the crown, taken from the root in one piece, and sent to the laboratory for casting procedures (Fig. 20.40). After casting (Fig. 20.41), post core is cemented and the excess cement is cleaned with appropriate instruments after setting (Fig. 20.42). The existing crown is cemented with the RPD afterward and delivered to the patient (Fig. 20.43).

Fig. 20.39 In order to restore a damaged abutment tooth with the aid of root support, a post core restoration may be made. First, a post core fitting the existing crown is made with an autopolymerizing acrylic resin (pattern resin)

Fig. 20.40 Make sure that the acrylic core fits the existing crown exactly

It is also possible to restore a damaged abutment tooth in a one-appointment visit by using screw or fiber-reinforced composite post systems following a proper root canal treatment (Fig. 20.44). The core part should be prepared with the aid of the existing crown with an appropriate restorative material and the crown is cemented with the RPD afterward (Fig. 20.45).

20.3.6.2 Fabricating a New Precision Attachment RPD Without Changing the Crowns

When an RPD with precision attachments has to be remade because of fracture of a major component or wear of the artificial teeth, the crowns fitting the RPD have also to be remade because they are fabricated together in order to make a

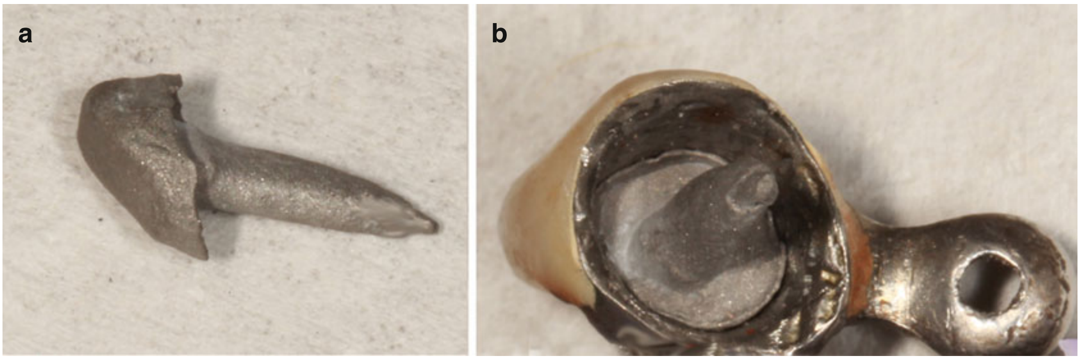

Fig. 20.41 The post core is cast with the selected metal alloy (**a**) and checked for fitting in the existing crown (**b**) before cementation

Fig. 20.42 Post core is cemented to the damaged crown and cleaned with appropriate instruments afterward

precise restoration. Since this procedure is time consuming and expensive, two methods which eliminate the crown work may be recommended. If the crowns can be removed from the abutments, an impression is made with the removed crowns in place with an irreversible hydrocolloid impression material (Fig. 20.46). The inner surface of the crowns are poured with an autopolymerizing acrylic resin and small die pins and the rest of the impression is poured with dental stone. The final cast is trimmed and made ready for the RPD framework fabrication (Fig. 20.47).

The other method eliminates crown removal and is thus more preferable for the patients. Patients can use their existing crowns and the RPDs until the new one is fabricated. In this method, an impression is made with an irreversible hydrocolloid or an elastomeric impression material. The negative duplication of the male components of the precision attachments are poured with an autopolymerizing acrylic resin (pattern resin) with small die pins and the rest of the impression is poured with dental stone (Fig. 20.48). The prepared cast is sent to the laboratory for the fabrication of new RPD framework (Fig. 20.49).

20.3.6.3 Activating or Changing the Attachment Components of RPDs

RPDs with precision attachments require maintenance after some time of usage. The wear of the plastic attachment components may cause loosening of the RPDs and therefore should be changed and the RPD is returned to the patient with the new attachments (Fig. 19.7) and a subsequent relining is performed if necessary. Additionally it is also possible to activate the components to increase retention if they permit activating like CEKA attachments with the use of suitable instruments provided by the manufacturers (Fig. 19.8). This procedure may be employed only if the retention is slightly lost. In case of larger loss of retention, the female attachment is probably worn and the spring pin is removed and changed with an oversized one (Fig. 20.50).

20.3.6.4 Maintenance of the Implant-Assisted RPDs

Maintenance of the implant-assisted RPDs are similar to the maintenance of implant retained overdentures. A complication mostly seen is the retention loss because of the wear of the plastic components and may easily be solved by activation or replacement of the matrix of the implant-assisted RPDs. Hence, it is very important for the

Fig. 20.43 The existing crown is cemented with the RPD; excess cement is cleaned (**a**) and the RPD is delivered to the patient (**b**)

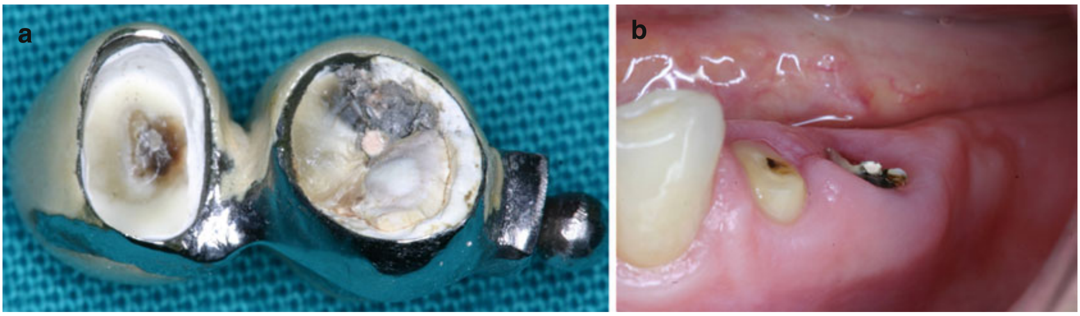

Fig. 20.44 The abutment teeth retaining a precision attachment RPD are broken (**a**, **b**)

Fig. 20.45 For a one-appointment restoration of the damaged abutment teeth, the root canal is enlarged, and using key, the post is dipped into cement and screwed into the root (**a**). The core part may be made with composite with the aid of the existing crown. The crowns are cemented to the restorated abutment teeth with the RPD (**b**) and the RPD is delivered to the patient (**c**) after cleaning the excess cement

clinicians to know the postinsertion maintenance requirements of each attachment type and choose the proper one that requires the least repairs. Plastic parts may be changed easily if no damage is seen in the abutments (Fig. 20.51). If wear of the abutments is evident (Fig. 20.52), it is not sufficient to replace only the plastic parts in the prosthesis; the abutments should also be changed to newer ones.

In the situation of canine-to-canine implant supported bridge and a distal end RPD (see Chap. 17), some problems may also occur. The bridge may be loosened and this may become a big problem for the patients. The bridge may be decemented or screw loosening may be seen if screw retained abutment system has been used (Fig. 20.53). Recementing with a more rigid permanent cement or tightening the screws with an

Fig. 20.46 When a precision attachment RPD has to be reconstructed, if the crowns are easily removed from the abutments, an impression is made with the removed crowns in place with an irreversible hydrocolloid

Fig. 20.47 The inner surface of the crowns are poured with an autopolymerizing acrylic resin and small die pins and the rest of the impression is poured with dental stone to obtain a definitive cast for the RPD framework fabrication

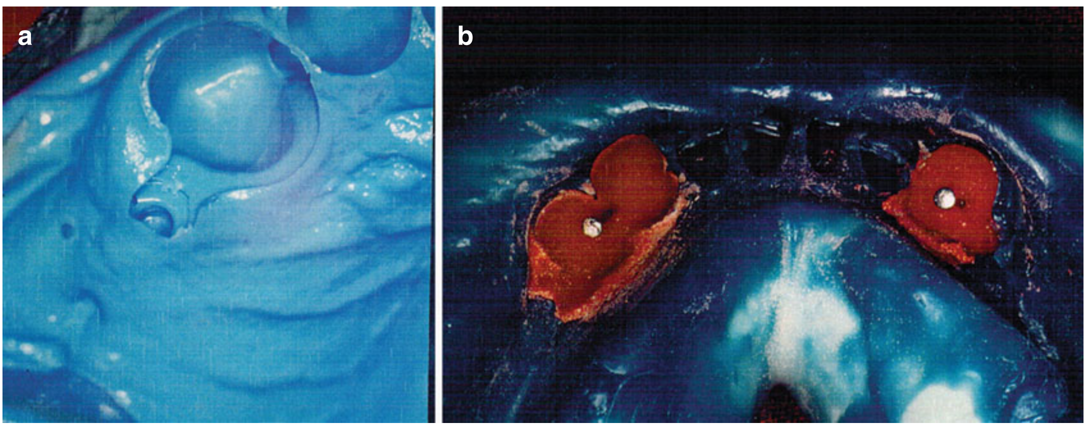

Fig. 20.48 An impression is made over the crowns with an elastomeric impression material (**a**). The negative duplication of the male components of the precision attachments are poured with an autopolymerizing acrylic resin with small die pins (**b**) and the rest of the impression is poured with dental stone

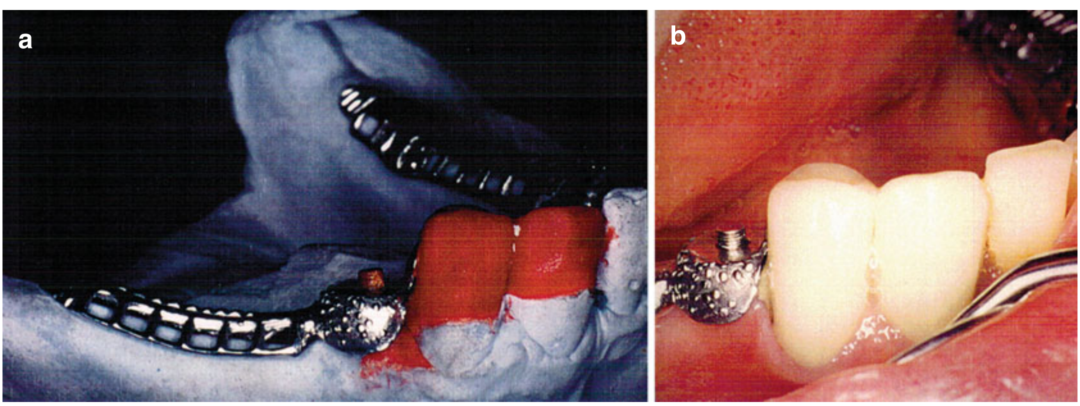

Fig. 20.49 The RPD framework is cast, checked on the cast (**a**) and intraorally (**b**)

Fig. 20.50 The spring pin may be removed and changed with an oversized one to increase retention

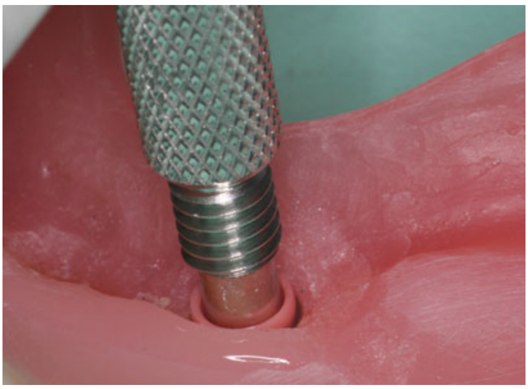

Fig. 20.51 Retention loss of implant-assisted RPDs may be recovered by changing the plastic attachment parts with the new ones

Fig. 20.52 In case of wear of the implant abutments, it is also necessary to change the abutments

Fig. 20.53 In the situation of canine-to-canine implant supported bridge and a distal end RPD the bridge may be loosened

appropriate torque with the aid of a torque wrench according to the manufacturer's recommendation may solve the loosening problem.

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Part VI

Re-establishing Normal Stomatognathic Function in Partially Edentulous Patients

21 Management of Temporomandibular Disorders (TMD) in Partially Edentulous Patients

Tonguç Sülün

21.1 Definitions

Grinding A term used to denote the act of correcting occlusal disharmonies by grinding the natural or artificial teeth.

Maximal intercuspal position (MIP) The complete intercuspation of the opposing teeth independent of condylar position, sometimes referred to as the best fit of the teeth regardless of the condylar position—called also maximal intercuspation.

Occlusal splint or device Any removable artificial occlusal surface used for diagnosis or therapy affecting the relationship of the mandible to the maxillae. It may be used for occlusal stabilization, for treatment of temporomandibular disorders, or to prevent wear of the dentition.

Retruded contact position (RCP) That guided occlusal relationship occurring at the most retruded position of the condyles in the joint cavities. A position that may be more retruded than the centric relation position.

Temporomandibular disorders (TMD) 1: Conditions producing abnormal, incomplete, or impaired function of the temporomandibular joint(s). 2: A collection of symptoms frequently observed in various combinations first described by Costen (1997), which he claimed to be reflexes due to irritation of the auriculotemporal and/or chorda tympanic nerves as they emerged from the tympanic plate caused by altered anatomic relations and derangements of the temporomandibular joint associated with loss of occlusal vertical dimension, loss of posterior tooth support, and/or other malocclusions. The symptoms can include headache about the vertex and occiput, tinnitus, pain about the ear, impaired hearing, and pain about the tongue.

21.2 Relationship Between Partial Edentulism and TMD

There is no universally accepted etiological factor of temporomandibular disorders according to the recent literature. Some studies suggested that partial edentulism has only a minor role in the etiology of temporomandibular disorders (TMD). Although some cadaver studies are able to show the relationship between posterior tooth loss and arthritic changes in temporomandibular joint, there is a consensus in the literature that the causal relationship between occlusion and TMD does not appear. Tooth loss and osteoarthritis (OA) is a natural progression

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of aging. Thus, the weak correlation between OA and tooth loss has to be reconsidered according to this fact. The historical studies especially from the 1970s speculated a close relationship of the above-mentioned topic using mostly the biomechanical theory. Later studies however confuted this theory. The clinical signs and symptoms of TMD are not always correlated with the anatomical changes in TMJ. Therefore, the results of the clinical researches are more important compared to the cadaver and radiological studies. These studies are also not able to evaluate muscle symptoms of the patients. Consequently, recent clinical studies show weak or no correlation between TMD symptoms and lack of molar support. Additionally, the studies analyzing "shortened dental arch theory" are in consensus that the lack of molar support is not a risk for the development of TMD. This topic was explained in Chap. 5 in detail.

Some studies have shown that the loss of a specific tooth may be associated with the development of TMD. Kirveskari and Alanen (1985) have shown that loss of maxillary first premolar tooth has an association with TMD. In another study by Abdel-Fattah (1996), it was shown that the loss of first molar tooth is related with TMD signs and symptoms. In a clinical study with better statistical analyses, Wang et al. are able to show that not only the number of missing posterior teeth but the number of dental quadrants with missing posterior teeth has an effect on the development of TMD. These studies based their results on the premature contacts and loss of the biomechanical balance as a result of drifting and tipping of the remaining teeth.

As a conclusion, recent literature does not support a sound relationship between partial edentulism and TMD. However, there are some good researches to point out that tooth loss and occlusal discrepancies may have an impact on the development of the functional disorder of the stomatognathic system. In future, the scientists have to focus more on longitudinal studies to show the long-term effect of occlusal changes and the lack of biomechanical stability on the masticatory system disorders.

Now the question is: Should we focus on the replacement of missing posterior teeth to treat the patients with TMD, even though there is no evidence to show such a relation? First of all, we have to discuss the effect of occlusal therapy in the treatment of TMD. Recent literature can show only a short-term success of occlusal therapy. Longitudinal studies are not enough to demonstrate a distinction of irreversible occlusal corrections (occlusal grinding or restoration) to more conservative and simple treatment modalities like occlusal splints or physical therapies. There are however a lot of studies that support the success of occlusal splint therapy in rehabilitation of the patients with TMD. Other studies are also not able to show a positive effect of placing fixed or removable prosthesis in the treatment of TMDs, especially if the patient has lost only his/her molar teeth. Thus, there is no need to choose a sophisticated prosthodontic treatment modality for the rehabilitation of the signs and symptoms of TMD. However in some cases with partial edentulism, there is a need of replacement of missing teeth to make a stabilization appliance. The aim of this chapter is to make clear how to construct an occlusal appliance in various partial edentulism situations.

21.3 Occlusal Splints

The occlusal splint therapy is based on changing the occlusal relations. However, that does not mean that the occlusal relations have to be restored or be adjusted in similar ways. In many cases, there is no need for a definite occlusal rehabilitation after the occlusal splint therapy. The occlusal splint therapy is finished after the symptoms of the patient diminish. The treatment should be restarted when the symptoms are returned after the end of the splint therapy. If a definitive therapy with occlusal splint is not possible, an irreversible occlusal rehabilitation should be evaluated. Yet, it should be kept in mind that there is no scientific evidence in dental literature that irreversible changes in dental occlusion help to reduce the symptoms of TMD.

21.3.1 How Do Occlusal Splints Rehabilitate TMD

1. *The increase of the occlusal vertical dimension*

   The occlusal splints are interocclusal devices which increase the occlusal vertical dimension of the patient for a temporary period. This is a very important characteristic of the occlusal splints. This increase elongates the masseter, temporal, and medial pterygoid muscles, which reduce the isometric contractions. It is well known that the isometric contractions of the muscles can expose myogenic pain. In contracted muscles, the blood circulation is blocked. That means the muscle cannot be nourished and purged. And the pain revealing particles collect in the muscle and expose pain. The physical therapy modalities generally function with this mechanism. The muscle is heated using infrared, laser, massage, etc., and the blood circulation is regenerated. Therefore, occlusal splints achieve this goal without using any physical therapy if the patient has bruxism.
2. *The change of the condyle position*

   Placing an occlusal splint into the mouth of the patient creates a new position of the condyles in the glenoid fossa which is more anterior and caudal to the centric position. Thus, the overload in the articular soft tissues is reduced.
3. *New occlusal relations*

   An occlusal splint should have a flat occlusal surface which eliminates the occlusal interferences and builds point contacts with each antagonist teeth. These kinds of splints create a harmonic slide between maximal intercuspal position (MIP) and retruded contact position (RCP). Additionally, a stabilization splint should have a canine guided eccentric occlusal balance. Especially the occlusal point contacts are perceived from the proprioceptive receptors in periodontium, and this information is sent as an impulse to the central pattern generator (CPG) in the brain. Thus, a decrease of muscle contraction is achieved.

Also, the cognitive awareness of the patient and the placebo effect of the occlusal devices are also important factors for the relief of the sign and symptoms of TMD.

21.3.2 Occlusal Splint Design in Partial Edentulism

First of all, the clinician should decide which jaw is appropriate for fabricating an occlusal splint. Therefore, the position, number, and size of the edentulous places should be analyzed. The following rules are helpful for a clinician to make the decision:

1. In cases with single (maxillary or mandibular) long free-ending edentulous arches (unilateral or bilateral), the antagonist jaw (full dentate or with a dentition which is explained in third entry) is ideal to place an occlusal splint and the edentulous jaw should be rehabilitated using an RPD (Fig. 21.1a–c). It is not suitable to make a stabilization splint over an RPD and it is also not correct to place a splint to a dental arch with a long free-ending edentulism. It may produce a tilting force on the anterior teeth because of the resilience of the mucosa (Fig. 21.2a, b). An alternative is to make a special designed occlusal splint for only night time use (Fig. 21.3a–f).
2. In cases with both maxillary and mandibular long free-ending edentulous crest (unilateral or bilateral), the patient should be rehabilitated first with RPDs. Afterward, a specially designed maxillary occlusal splint should be prepared for nighttime use.
3. In cases with edentulous gaps or short free-ending situations (e.g., absence of second molar tooth unilateral or bilateral), the replacement of tooth loss can be done by using the occlusal splint. In such cases, the splint should be placed to the jaw with more tooth loss (Fig. 21.4a, b).
4. In cases with mandibular partial and maxillary complete edentulism, a mandibular RPD and maxillary complete denture should be prepared if the patient has no prosthesis at all. For nighttime use, an additional upper denture (so-called Shore denture) should be placed to function as an occlusal splint (Fig. 21.5a, b).
5. In cases with mandibular full edentulous arch and maxillary partial edentulism, occlusal splint therapy is contraindicated because of the poor support of mandibular alveolar crest. If the mandibular denture is supported with implants, Shore prosthesis could be constructed for the lower jaw.

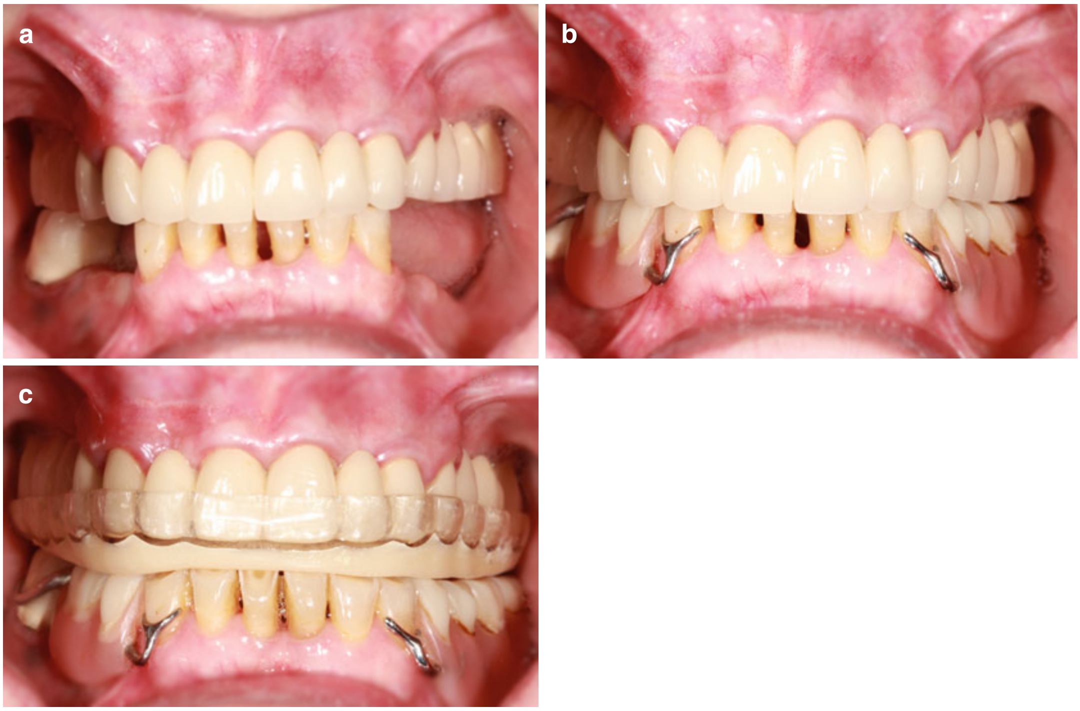

Fig. 21.1 (**a**) A temporomandibular disorder (*TMD*) patient with mandibular partial edentulism. Intraoral view in occlusion. (**b**) A removable partial denture (*RPD*) is fabricated for the patient first. (**c**) Then a maxillary occlusal splint is fabricated

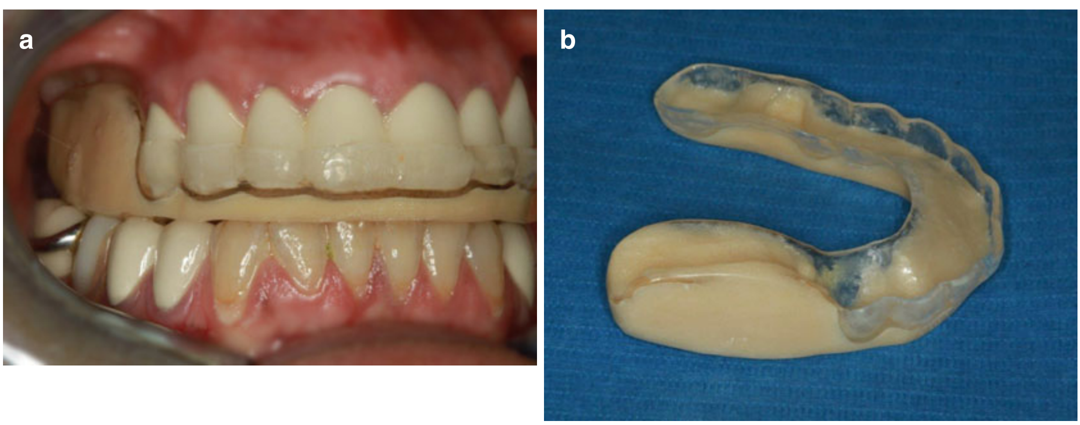

Fig. 21.2 (**a**) An occlusal splint is fabricated to a patient with a long free-ending partial edentulism. (**b**) Notice the long distal part of the occlusal splint, which may produce a tilting force on the anterior teeth

Fig. 21.3 (**a**) A temporomandibular disorder (*TMD*) patient with maxillary partial edentulism. Intraoral view in occlusion. (**b**) The metal framework of the specially designed occlusal splint. Occlusal view. (**c**) Occlusal splint after positioning using cold curing resin. Occlusal view. (**d**) Occlusal splint after positioning using cold curing resin. Inner view. (**e**) Specially designed occlusal splint in the mouth of the patient in occlusion. (**f**) The occlusal point contacts for each antagonist teeth

Fig. 21.4 (**a**) A mandibular occlusal splint that also replaces the second molar tooth. (**b**) The occlusal splint in the mouth of the patient

Fig. 21.5 A case with maxillary complete and mandibular partial edentulism that needs temporomandibular disorder (*TMD*) management. (**a**) A maxillary complete and mandibular removable partial denture is fabricated. (**b**) A maxillary Shore prosthesis is fabricated for nighttime use as an occlusal splint

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22 Re-establishing Occlusal Vertical Dimension and Maximal Intercuspal Position in Partially Edentulous Patients

Olcay Şakar

22.1 Definitions

Occlusal vertical dimension (OVD) The distance measured between two points when the occluding members are in contact.

Rest vertical dimension (RVD) The distance between two selected points measured when the mandible is in the physiologic rest position.

Physiologic rest position (PRP) The mandibular position assumed when the head is in an upright position and the involved muscles, particularly the elevator and depressor groups, are in equilibrium in tonic contraction, and the condyles are in a neutral, unstrained position.

Vertical dimension of speech That distance measured between two selected points when the occluding members are in their closest proximity during speech.

Vertical dimension decrease Decreasing the vertical distance between the mandible and the maxillae by modifications of teeth, the positions of teeth or occlusion rims, or through alveolar or residual ridge resorption.

Vertical dimension increase Increasing the vertical distance between the mandible and the maxillae by modifications of teeth, the positions of teeth, or occlusion rims.

Centric relation (CR) The maxillomandibular relationship in which the condyles articulate with the thinnest avascular portion of their respective disks with the complex in the anterior-superior position against the shapes of the articular eminencies. This position is independent of tooth contact. This position is clinically discernible when the mandible is directed superior and anterior. It is restricted to a purely rotary movement about the transverse horizontal axis.

Interocclusal rest space (IORS) The difference between the vertical dimension of rest and the vertical dimension while in occlusion – called also freeway space.

Maximal intercuspal position (MIP) The complete intercuspation of the opposing teeth independent of condylar position, sometimes referred to as the best fit of the teeth regardless of the condylar position – called also maximal intercuspation.

Retruded contact position (RCP) That guided occlusal relationship occurring at the most retruded position of the condyles in the joint cavities. A position that may be more retruded than the centric relation position (centric relation).

Overlay removable partial denture (ORPD) ORPDs a subset of overdentures;

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are often referred to as removable partial dentures that have part of their components covering the occlusal surface of the abutment teeth to restore them into a functional occlusion.

22.2 Basic Principles of Re-establishing Occlusal Vertical Dimension and Maximal Intercuspal Position in Partially Edentulous Patients

Occlusal vertical dimension loss may occur due to various reasons described in detail below. At the same time, it may be necessary to increase the OVD in patients with no loss of OVD to gain sufficient space for a prosthetic restoration. Which methods can be used to re-establish occlusal vertical dimension and maximal intercuspal position? How much can occlusal vertical dimension be increased? Is there any limitation and/or contraindication? How long is the period of adaptation and which control methods are used in this period? What is the role of overlay removable partial dentures and what are the issues to be considered in the laboratory and clinical procedures during the prosthetic treatment? This chapter will be a guide that can be used not only in cases of partial edentulism but also in all cases to re-establish the occlusal vertical dimension and maximal intercuspal position.

22.2.1 The Main Reasons for the Decreased Occlusal Vertical Dimension in Dentate Individuals

Natural and artificial tooth wear, tooth loss, and migration of the teeth may result in the loss of occlusal vertical dimension. In addition, patients with severe dental and skeletal malocclusions, and acquired and congenital anomalies, may need re-establishment of occlusal vertical dimension and maximal intercuspal position.

22.2.1.1 Tooth Wear

Attrition, erosion, and abrasion are the main ways that the teeth become worn. In contrast to the past, dental erosion is now considered to be a major cause of tooth wear, and dental wear can be seen not just in older population but also among young people. As tooth wear is a natural process it generally does not need any specific treatment, especially if the patient has a proper adaptation. However, the severity of the wear according to morphological changes and the potential for progression in the context of the patient's age should be the determining factors.

In some cases tooth wear occurs, but at the same time tooth surface loss is compensated by continuous tooth eruption and alveolar bone growth. Thus the OVD remains the same or it is still acceptable without the need to be increased (Fig. 22.1a, b). If a restoration is necessary, the

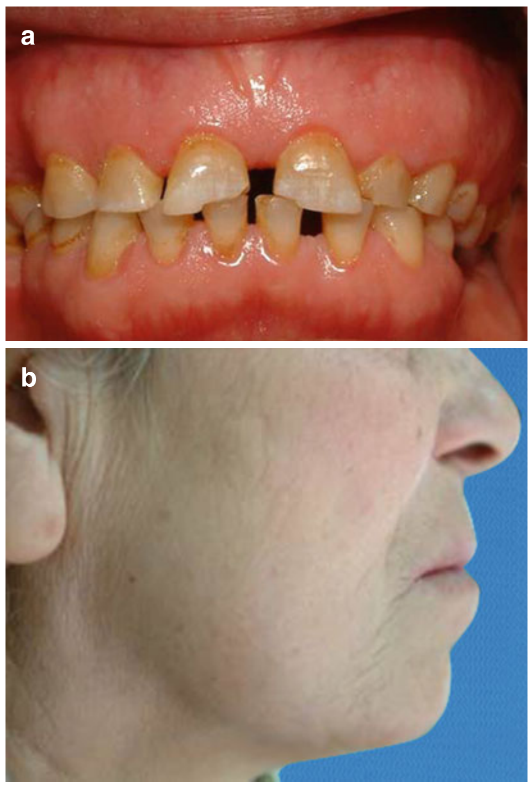

Fig. 22.1 (**a**, **b**) In some cases, tooth wear is accompanied by alveolar bone growth and continuous tooth eruption. Thus, the occlusal vertical dimension cannot be decreased. If necessary, treatment alternatives should be applied before increasing the OVD

Fig. 22.2 (**a**–**g**) Intraoral examination revealed localized anterior tooth wear (**a**, **b**) and extraoral examination showed that there is no decrease in OVD (**c**). A composite Dahl restoration has been applied to gain sufficient space for prosthetic restoration and posterior disclusion was created (**d**). One year after composite resin restoration has been applied and occlusion was re-established (**e**). View of space gained at anterior region after the composite restorations were removed (**f**). Postoperative view with metal-ceramic restorations (**g**)

treatment options may include periodontal surgery to gain clinical crown length and orthodontic movement with limited intrusion. In many cases, only the anterior segments may have been worn. If there is no loss of OVD, a less radical alternative to complete restoration, based on the principles of combined forced intrusion of anterior teeth and supra eruption of posterior teeth, was first described by Dahl et.al. An anterior cobalt-chromium removable splint, resin-bonded cast, or composite restorations to accomplish this procedure (Fig. 22.2a–g), or temporary crowns can be used. As well as the

"Dahl technique" space may be gained if a large horizontal discrepancy exists between retruded contact position and the maximum intercuspal position, but with little vertical discrepancy, occlusal adjustment of such "centric interferences" will produce a significantly more distal MIP and thereby sufficient palatal space for the full construction of anterior restorations. In cases where the natural mechanisms fail to compensate for tooth wear the loss of OVD will occur. Consequently, the collapse of the anterior lower facial height requires an increase to restore the subjects to their original OVD. This will create the requisite interocclusal space for the restorative material. Where there is general loss of vertical tooth height, careful management of the remaining tooth structure for the retention and resistance of the restoration is needed. Recommended minimal preparation height is at least 3–4 mm. If OVD increases, it is possible to make a crown restoration with this height of clinic crown without additional treatment (such as crown lengthening surgery).

Therapy for patients with reduced vertical tooth height includes management of gastroesophageal reflux disorder, dietary advice, fluoride application, monitoring parafunctional habits, and supporting changes in lifestyle.

After elimination of the risk factors of the tooth wear, an overlay removable partial denture can be both an interim and permanent treatment option. It is important to be aware that erosive wear may continue under the ORPDs and the occlusal splints if patients do not take proper care of cleaning their denture or occlusal splint or fail to maintain oral hygiene. Regular observation of patients with tooth wear is necessary.

22.2.1.2 Tooth Loss and Migration of the Teeth

Occlusal interferences can be created by the overeruption caused by clinically unopposed teeth. In some patients tooth loss may result in a decrease of the OVD. The potential restoration area may be occupied with migrated teeth and/or the alveolar process. In some cases, in spite of the presence of tooth loss and/or migrating of the teeth, decrease in OVD may not be observed. Alternative treatments such as alveoloplasty, orthodontic movement with intrusion, and crown restorations should be performed before increasing OVD (Fig. 22.3a–f). Although it is possible to gain space for a restoration with the above-mentioned treatments, for some patients with loss of OVD increasing OVD enables occlusal reorganization and the establishment of an even occlusal plane (Fig. 22.4a, b). In this way, tooth or tissue structure may not need to be sacrificed.

22.2.1.3 Congenital and Acquired Anomalies

Congenital and acquired anomalies can include amelogenesis or dentinogenesis imperfecta, cleidocranial dysostosis, and cleft palate. Patients with these conditions present from birth may have severely abraded or eroded dentition, stained/ malformed teeth, or partial anadontia accompanied by loss of OVD. A removable partial denture is a solution to the esthetic and functional problems faced by these patients until they reach their maximum growth. In some patients with anomalies or syndromes, an ORPD can be a final treatment if interocclusal distance is too large to fabricate any other prosthetic restoration (Fig. 22.5a–i).

22.2.1.4 Severe Dental, Skeletal Malocclusions

Generally patients with Class III malocclusion need a prosthodontic treatment to satisfy esthetic and functional requirements. A maxillary skeletal deficiency, either alone or in combination with mandibular prognathism, can be an etiological factor in Angle Class III development. Dentoalveolar malrelation may also result in a Class III malocclusion. Frontal and profile extraoral examinations reveal reduced vertical facial height and also intraoral examination shows the negative horizontal overlap in these patients. Generally there is a big difference between maximal intercuspal position and retruded contact position and patients can rotate the mandible with help and the lower facial height can be returned to normal (Fig. 22.6). In this position a bilateral posterior open occlusal relationship is observed. Prosthetic rehabilitation may be indicated to re-establish an acceptable OVD and maximal intercuspal position (Fig. 22.7a–f).

In some patients, open occlusal relationships can be observed without any discrepancy between

Fig. 22.3 (**a**–**f**) In some cases without loss of OVD, an orthodontic treatment resulting in intrusion can be an alternative to gain adequate space for prosthetic restoration

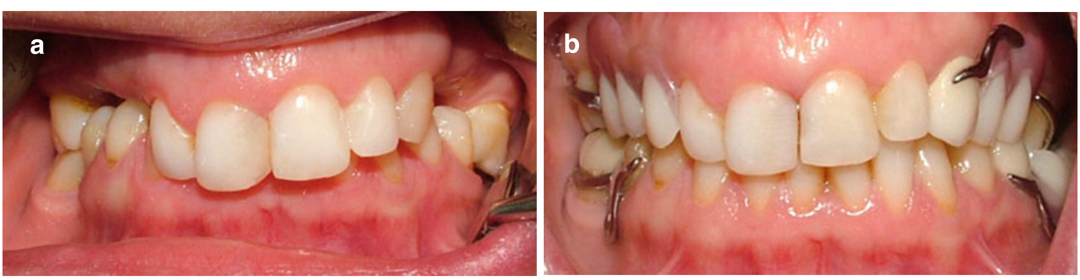

Fig. 22.4 (**a**, **b**) After 11 years of tooth loss without using any prosthetic restoration, migration of teeth accompanied by alveolar bone growth and loss of OVD were observed. Overlay removable partial denture was applied to re-establish OVD to provide functional and esthetic requirements

MIP and RCP. Open occlusal relationship is defined as "the lack of tooth contact in an occluding position." It can be anterior (the lack of anterior tooth contact in any occluding position of the posterior teeth) or posterior (the lack of posterior tooth contact in any occluding position of the anterior teeth). Although the condition may occur bilaterally, unilateral presentations are more frequent. The etiology is not well understood. A number of factors such as abnormal tongue function, primary failure of eruption, ankylosis of teeth, condylar trauma, or pathology have been associated with this condition. Although there is no loss of the OVD, a removable partial denture can be an alternative treatment option to create functional occlusion (Fig. 22.8a–e).

22.2.2 The Advantages and Possible Consequences of Increasing the OVD

In dentate individuals, the advantage of increasing the occlusal vertical dimension is to

1. Allow space for restorative material
2. Improve facial appearance
3. Rectify anterior teeth relationship
4. Provide for re-establishment of physiologic occlusion
5. Prevent or minimize procedures like crown-lengthening surgery and endodontic treatment
6. Protect tooth structure and/or sensitivity

After increasing OVD, some consequences may be expected such as hyperactivity of masseter muscles, elevation of bite force, bruxism, and temporomandibular disorders. However, the above consequences were not supported by evidence-based literature. It can be concluded from research findings that OVD can be increased without facing any serious complications, in full dentate, partial edentulous, and full edentulous cases. Because of the high probability of the collapse in OVD that may have occurred in patients, such as with pronounced antegonial notch, masseter hypertrophy, and bone exositosis in association with the increase in alveolar bone volume, increasing OVD should be avoided.

Fig. 22.5 (**a–i**) An ORPD and a tooth-supported maxillary complete denture have been preferred in a patient with Ehlers–Danlos syndrome, having loss of OVD with too large an interocclusal distance to fabricate any other prosthetic treatment alternatives

Fig. 22.5 (continued)

Fig. 22.6 In Angle Class III patients, generally there is a big difference between maximal intercuspal position and retruded contact position. Movie shows determining the discrepancy intraorally and extraorally. These patients are good candidates for re-establishing OVD to meet the esthetic and functional requirements. In patients not showing the discrepancy, increase in OVD should not be recommended or should be made as minimum as possible (Video 22.1)

22.2.3 Determining the Amount of Increase in OVD

Objective guidelines for the increase of the OVD may not be established with any certainty. One clinical variable is the IORS. The reason for measuring the IORS is to determine how the OVD can be altered. Details are given in the "determination of new OVD and evaluation of the adaptation period" section. At this point, dealing with increasing OVD in two different ways may be clinically more useful. Namely, if there is an obvious difference between OVD and RVD (more than 2–3 mm), OVD can be increased as much as required in order to satisfy functional and esthetic requirements. It can be

Fig. 22.7 (**a**–**f**) In Class III patients, negative horizontal overlap may result in reduced vertical facial height (**a**, **b**). Negative horizontal overlap and reduced vertical facial height can be corrected with the aid of orthodontic treatment (**c**). An overlay removable partial denture was used both in adaptation and retention period (**d**). Prosthodontic treatment was finalized with mandibular fixed and maxillary precision attachment RPD (**e**, **f**)

termed *re-establishment of OVD*. But if the IORS is 2–3 mm and increasing OVD is still needed to provide adequate space for the restorations, a minimal increase in OVD should be made. It can be termed *actual increasing of OVD*. Increasing OVD should be kept to a mini-

Fig. 22.8 (**a**–**e**) Maxillary laminate veneer restorations and a mandibular overlay removable partial denture have been fabricated in a patient having open occlusal relationships, with the need of minimal invasive restorations because of systemic health problems. The loss of OVD is not generally observed in these cases. (**a**) Intraoral view. (**b**, **c**) Base plate for esthetic verification. (**d**, **e**) Final restorations

mum (recommended amount max: 4–5 mm) (Fig. 22.9a–f).

22.2.4 Adaptation Period and Methods of Increasing OVD

The ratio of patients who adapted to the increase in the OVD can be termed the adaptation level. The time required for adaptation to the increase in the OVD is the adaptation period. With removable prostheses, the adaptation level has been found to be 86–100 % and the adaptation period varies from 2 days to 3 months.

In the adaptation period, a detailed evaluation should be made. Any adjustments of the temporary restorations can then be performed according to the needs of the patient.

The use of removable interocclusal appliances (occlusal splints) in the adaptation period is not indicated, except in temporomandibular disorder patients. First of all, the use of occlusal splints might expose signs and symptoms relating to occlusal splint wearing instead of increased OVD. Secondly, it is not possible to

Fig. 22.9 (**a**–**f**) Although there is tooth loss (**a**–**d**), decrease in OVD may not be observed (e). Such patients should be treated with a minimum increase in OVD required for the restoration (**f**) and followed at short intervals by checking occlusion for possible collapse

evaluate chewing function, speech, and esthetics with occlusal splint usage in the adaptation period.

Although for patients the use of fixed temporary prostheses seems more comfortable than the removable prostheses, before the irreversible tooth preparation it is wise to use ORPDs in the adaptation period.

The determination of the static and dynamic occlusion was described in Chap. 13 in detail. Briefly, in general, it may be emphasized that retruded contact position for static occlusion, canine guidance for dynamic occlusion are the first choices for cases requiring extensive occlusal rehabilitation.

22.2.5 Determination of New OVD and Evaluation of the Adaptation Period

When re-establishing OVD, the method of determining the new OVD is based on complete denture fabrication procedures. Unfortunately there is no exact means of doing this and more than one following method should be used to determine whether OVD has been altered and the new OVD.

1. Interocclusal rest space : MIP and original OVD of the existing dentition are evaluated. Then IORS is determined. It is very important to keep in mind that the determination of the IORS has many restrictions.
   (a) Physiologic rest position can change in different examination periods even during the same appointment for the same patient.
   (b) Loss of OVD may be associated with a similar loss of RVD.
   (c) Physiologic rest position occurs at a zone rather than a specific level.
   (d) Evaluation of the rest vertical dimension can vary from clinician to clinician for the same patient. Accurate determination of the IORS is difficult when the landmarks are located on movable skin tissues. When skin measurements are used, the tip of the nose-chin distance appears to be more reliable than the subnasal-chin distance. The interocclusal rest space of more than 2–3 mm may indicate loss of OVD.

       The clinical studies showed that the increasing OVD beyond IORS (approximately 4–5 mm inter-incisally) did not result in any adaptation or pathological problems. However, in these studies, distinction between the actual increasing and re-establishment of OVD has not been emphasized in general.
2. Phonetic evaluation: Speech, particularly the use of sibilant or "s" sounds, is a better method than using interocclusal rest space for determining an acceptable OVD. The closest speaking space (CSS) is the minimum distance between the anterior teeth that occurs during the pronunciation of words containing "s," "e," and "i" sounds. Average closest speaking space values of 1–3 mm can be used in the clinical determination of occlusal vertical dimension of prosthetic restorations, regardless of dental and skeletal classified occlusions. The closest speaking space does not differ between males and females and no correlation was found between the amount of vertical overlap and the closest speaking space. The closest speaking space of more than 1–3 mm may indicate loss of OVD.

   Evaluation of the closest speaking space is also the most effective way to assess a patient's adaptation to the new OVD. If the teeth strike each other when the patient attempts to speak, the determined OVD is excessive and should be reduced. It is necessary to hold the articulating paper between the teeth and have the patient say English words "sixty-six" or "Mississippi" and non-English words "sessantasei," "seyis," or "seis" and adjustments are performed. If after 1 month the patient is still experiencing difficulty with speech, the point of tooth contacts is again adjusted, either off the maxillary or mandibular tooth, and the process is repeated until there are no more contacts present during the pronunciation of these words. More time may be required for adjustment until the speech problems are resolved.

   It is important to remember that while most patients protrude their mandible to the end-to-end position, others use the retruded position when producing "s" sounds and modifications in the form of the restorations would be more necessary in the former group of patients. Phonetic evaluation, along with monitoring the patient's adaptive capacity, is much more important when actual increasing of the OVD was performed. The vertical change itself may be less stable and the patient's occlusion may need more adjustment.
3. Facial appearance and measurements: The OVD is an important factor that affects esthetics. Sagittal and frontal facial tissue appearance, lip morphology, and teeth display are elements that need to be considered. Proportional face measurements and evaluation of the facial appearance are also used to determine OVD; such as when teeth are in maximal intercuspal position, there should be equality between the distance from the bony shelf under the nose to the bottom of the mandible and the distance from the pupil of the eyes to the rima oris.

   Mandibular pseudoprognathism, which may be a sign of the OVD loss, can be

Fig. 22.10, 22.11, 22.12, 22.13, 22.14 and 22.15 As there is no exact method to determine the OVD, clinical observation of the patient is very important to determine the amount of loss of OVD. Videos show the frontal and profile appearances when the patients move their mandibles between RVD and OVD in addition to CSS during speech. IORS in normal OVD (Fig. 22.10, Video 22.2). CSS in normal OVD (Fig. 22.11, Video 22.3). Intraoral view of the patient having normal OVD (Fig. 22.12). IORS in decreased OVD (Fig. 22.13, Video 22.4). CSS in decreased OVD (Fig. 22.14, Video 22.5 – the patient's lips were retracted for demonstrative purposes). Intraoral view of the patient having decreased OVD (Fig. 22.15)

observed from the sagittal view. Nasolabial and mentolabial angles are also evaluated.

From the frontal view, diminished facial contour, deep folds in the commissures of the mouth, thin lips, presence of angular cheilitis, and loss of muscle tone with the face appearing flabby instead of firm are typical facial aspects associated with the loss of OVD (Fig. 22.5c). When re-establishing OVD, it is necessary to pay particular attention to lip closure. Patients should be able to close their lips comfortably without any tension.

As a conclusion, evaluating all above-mentioned factors is essential to determine the amount of the loss of OVD. The movies show the sagittal and facial views of patients having normal and decreased OVD when their mandibles move between OVD and RVD, and the CSS during the pronunciation of the word "seyis" (Fig. 22.10, 22.11, 22.12, 22.13, 22.14 and 22.15).

It is important to remember that increasing OVD should be resisted simply for esthetic reasons in patients without functional disturbances, such as severe tooth wear or chewing problems.

22.3 Overlay Removable Partial Dentures

In partially edentulous patients, after the adaptation period of new OVD and MIP, final restoration can be performed with the fixed partial dentures, which is beyond the scope of this book.

Implant-assisted RPDs or RPDs with precision attachments can also be used. These treatment alternatives are defined in the relevant chapters.

In contemporary dentistry, emphasis should be placed on conservative management strategies. ORPDs, which will be focused on this chapter, can be both provisional and definitive treatment options to re-establish OVD and MIP.

22.3.1 Advantages of ORPDs

1. Can be a treatment alternative if the interocclusal distance is too large for metal ceramic restorations besides in the presence of periodontally compromised and/or doubtful endodontically treated teeth, which are unsuitable for clasping.
2. Effective and financially viable, as well as esthetically pleasing to patients.
3. Simple treatment alternative to geriatric patients who are not able to tolerate invasive treatment options and also to pedodontic patients who are still actively growing and will need several new prosthesis during maturation.
4. Noninvasive, reversible, and conservative treatment option.
5. Possible to evaluate the esthetics, phonetics, occlusion, and function with ORPDs during the adaptation period of newly established OVD and MIP.
6. Can be fabricated minimal or no tooth preparation.
7. Rest seat preparations not needed because the entire occlusal surface of all the teeth serves as a rest seat under the cast framework.
8. Natural teeth which are not suitable for other types of restorations can be preserved under the ORPD to avoid the alveolar bone resorption

22.3.2 Potential Disadvantages of ORPDs

1. When dentures are removed and the color of the esthetic material is incompatible with the color of the natural teeth, esthetics may be compromised and also the presence of metal clasp retainers may negatively affect the esthetics.
2. Erosive wear may continue or dental caries may occur under the ORPDs if patients are not motivated enough to maintain good oral hygiene.
3. Esthetic material wear, fracture, debonding, or discoloration may take place.
4. Hard palate coverage with the major connector and increased size and thickness can be irritating for the patient. If there are enough abutment teeth, an ORPD can be fabricated without a major connector. But in patients with extensive hard and soft tissue defects, such as cleft palate, a major connector should be used.

22.3.3 Occlusal and/or Esthetic Materials for ORPDs

Composite and acrylic resins, porcelain, acrylic resin teeth, and metal occlusal surface can be used as occlusal and/or esthetic materials in ORPDs. While deciding on the esthetic material, the following factors should be considered: porcelain veneers are superior to acrylic resin regarding the color stability and esthetics. Acrylic resin and acrylic resin teeth can be easily repaired and they are cost-effective, compatible with most dental alloys, time saving, simple to produce, and may have reasonably good esthetics. The retention of the resin to the metal is mainly mechanical, but porcelain veneers need a bonding agent to compensate for different expansion coefficients between metal and ceramics and blocs escaping metal oxides. While porcelain materials are more suitable for the rigid areas of ORPDs because of their low deformation at the yield point, acrylic materials are more suitable for the flexible areas of the denture because of their high compressive load and yield strength. Thus, if the patient is a bruxer, composite or acrylic resin should be selected as an esthetic material and a different RPD design can be used as an occlusal splint for the nocturnal usage (see Chap. 21).

Fig. 22.16 The amount of increase in the occlusal vertical dimension required for the restoration can easily be visualized by using the sliding guide placed between the incisors in cases having anterior teeth

22.3.4 Clinical Procedures for Fabricating an Overlay Removable Partial Denture

1. The new OVD and RCP are determined as with the edentulous patients described above. When actual increasing OVD is performed, sliding guide and leaf-wafer can be used to establish OVD and RCP records. The minimum amount of increase in the occlusal vertical dimension required for the restoration can easily be visualized by using the sliding guide (Fig. 22.16).
2. The diagnostic casts are mounted on a semiadjustable articulator. Depending on the interocclusal distance, both temporary and final treatment options are assessed. Esthetic and functional evaluation should be performed before the final decision. Acrylic resin crowns, ORPDs, and also composite onlays can be used as temporary restorations. If the interocclusal distance is small, it is possible to make an esthetic verification and temporary restorations with composite material. If the interocclusal distance is large, esthetic verification can also be made using base plates shaped with white acrylic-resin that covers the occlusal, buccal, or incisal part of the teeth (Fig. 22.8b, c).
3. If necessary, recontouring and polishing of unsupported enamel or infrequently a “dimpling” procedure can be used to provide retention on posterior abutments that have unsufficient undercut for buccal clasps. Additionally in some instances, facial reduction of enamel surface in the esthetic zone is required to accommodate the veneers which would be fused to the ORPD and, in the cases of missing natural undercut for adequate retention, guide planes are placed on proximal tooth surfaces.
4. As a general rule, 2–3 mm of interocclusal space should be present in the anterior region beyond the patient’s OVD. This would allow for approximately 0.3–0.5 mm of space in the most posterior region, which is needed for the structural integrity of an all-metal occlusal surface. Metal on labial and buccal surfaces may be thinned to approximately 0.2 mm. An effort should be made to limit labial or buccal thickness to 1–1.5 mm, including metal, opaque, and composite resin, to provide proper esthetics and avoid fracture of the resin at peripheries (Fig. 22.17 a–d).
5. The casts should be surveyed to determine the most desirable path of placement (see Chap. 14). If necessary, retention beads are placed for the veneering material on the occlusal and facial surfaces where it is

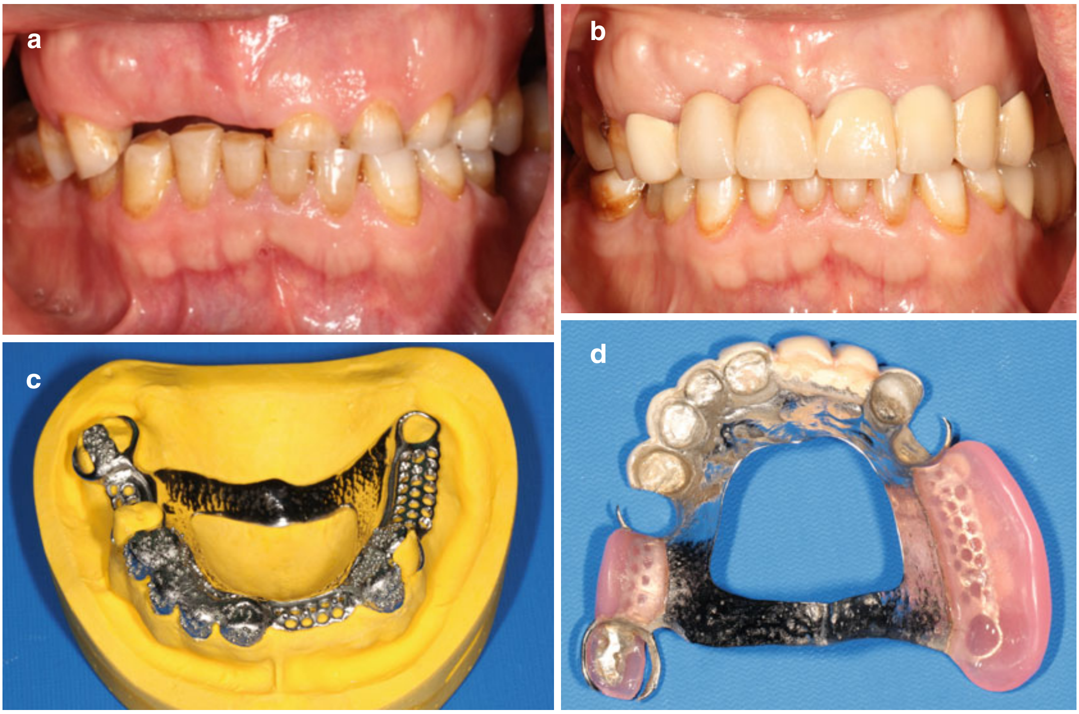

Fig. 22.17 (**a**–**d**) In some cases, the ORPD framework may be extended to the buccal surfaces. If necessary, preparation is performed on the natural teeth and metal may be thinned to approximately 0.2 mm

needed. The framework is generally cast in a Co-Cr alloy.

6. The framework is tried in. With the framework in position, OVD-RCP records are verified. If necessary, the definitive cast is remounted on the semiadjustable articulator. Artificial teeth are arranged and veneering material is applied then.
7. New OVD-RCP records and dynamic occlusal relationships during esthetic try-in are verified in the mouth.
8. The patient is instructed to clean ORPDs with a nonabrasive paste after every meal and especially after the consumption of acidic beverages. The importance of cleaning the internal surface of the prosthesis as well as their own teeth must be emphasized. Additionally, patients are advised to use a fluoride gel as an anticaries preventive measure. After thorough cleaning of both prostheses and teeth, the fluoride gel is placed inside the ORPD and then inserted in the mouth.

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