Chapter 8

Implant-Supported Removable Prostheses

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Abstract

Despite advances in preventive dentistry, tooth loss remains a significant concern, affecting oral and overall health. It leads to functional, aesthetic, and psychological challenges, impacting the quality of life. Major contributing factors include periodontal diseases, age, socioeconomic status, and poor oral hygiene. Partial edentulism, particularly free-end cases in posterior regions, is commonly treated with removable dentures, which, over time, accelerate bone loss and compromise prosthesis stability.

Implant-supported prostheses offer superior stability, function, and bone preservation compared to traditional removable dentures. In fully edentulous patients, the most common approach involves two implant-supported overdentures in the mandible, while at least four implants are recommended for the maxilla. Treatment planning should consider bone volume, patient expectations, and biomechanical requirements. Implant-supported prostheses help maintain occlusal balance, enhance chewing efficiency, and improve overall well-being.

Long-term implant success depends on proper maintenance and periodic follow-ups. Immediate loading protocols provide faster rehabilitation but require optimal primary stability. Additionally, occlusal considerations and prosthetic design play crucial roles in ensuring longevity and function. The increasing global demand for implant treatments highlights the need for comprehensive planning and patient education to prevent progressive bone loss and improve oral rehabilitation outcomes.

1.Implant-supported prosthesis requirement

Despite advancements in preventive dentistry, the prevalence of tooth loss continues to rise. Oral health plays a crucial role in overall well-being and is closely linked to quality of life. While general health was once considered

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the primary factor affecting quality of life, the significance of oral health in this regard has gained increasing recognition over time.(Oyar et al., 2019)

Tooth loss is a key indicator of oral health and is influenced by various factors, including age, gender, oral hygiene habits, socioeconomic status, excessive chewing forces, gingivitis, and periodontitis. Missing teeth can lead to functional impairments, speech difficulties, and aesthetic concerns, all of which negatively impact both oral and overall health. Therefore, addressing tooth loss through appropriate treatment is essential.(Guan et al., 2025)

According to the World Health Organization, an adult requires at least 21 functional teeth to maintain proper oral function.(Oyar et al., 2019)

The prevalence of partial edentulism is a growing concern, as the number of implants used to restore these cases continues to rise.The transition from having a full set of natural teeth to partial tooth loss is most prominent among individuals aged 35 to 54. This age group is experiencing a population increase of 30%, outpacing all other demographics. As a result, this shift is expected to lead to a significant rise in the demand for dental implant treatments in the coming years.(Chen et al., 2024) It is estimated that approximately 812 million people worldwide are potential candidates for dental implants. Tooth loss becomes increasingly prevalent with age, affecting different demographics at varying rates. Among individuals aged 25 to 44, around 120 million experience partial edentulism, while the number rises to 156 million in the 45 to 54 age group. The prevalence continues to increase in older populations, with approximately 200 million people aged 55 to 64 requiring implants. In the 65 and older category, the highest number of cases is observed, with 336 million individuals affected. These estimates highlight the growing need for implant treatments globally, though factors such as socioeconomic status, oral hygiene habits, and access to dental care influence the actual demand.(Bongaarts, 2020; Douglass & Watson, 2002)

Molars are the most frequently lost teeth, and the occurrence of partial free-end edentulism is particularly concerning, as it is commonly managed with removable dentures. While this condition is rarely seen in individuals under 25, its prevalence increases with age. The mandible is more frequently affected than the maxilla across all age groups. Among younger individuals aged 25 to 44, unilateral free-end edentulism is more prevalent than bilateral cases, impacting approximately 13.5 million people. (Karadi et al., 2024) By the ages of 45 to 54, about 31.3% of individuals experience mandibular free-end edentulism, whereas 13.6% have maxillary involvement, affecting nearly 9.9 million people. The condition worsens significantly in individuals

aged 55 to 64, with 35% of mandibular and 18% of maxillary arches being edentulous, making around 11 million people potential candidates for dental implants.(Al-Rafee, 2020)

2.Anatomical Changes Caused by Edentulism

Tooth loss leads to significant deformations, particularly in the alveolar bone structures. In this context, basal bone and alveolar bone exhibit different behaviors due to their distinct embryological origins. While the development of basal bone in the fetus occurs independently of dental bud formation, alveolar bone development begins with the formation of the epithelial tissue of the dental buds. Essentially, this phenomenon is the primary reason for the lifelong physiological dependency between alveolar bone and dental tissues.(Chen et al., 2010)

Additionally, according to Wolff's law, bone continuously remodels itself in response to the mechanical forces it is subjected to. The shape of the bone is influenced by abnormal loads or functional losses in the surrounding tissues. The morphology and density of the bone rely on mechanical stimulation to maintain their physiological integrity.(Frost, 2004) Teeth transmit pressure and tensile forces to the surrounding structures through their periodontal tissues. This process generates a piezoelectric effect in the inorganic component of the bone. When a tooth is lost, the absence of mechanical stimulation leads to the atrophy of the alveolar bone. Research indicates that within the first year following tooth loss, bone width decreases by approximately 25%, while height loss reaches around 4 mm during the same period.(Jung et al., 1996)

Although the mandible initially has twice the bone height of the maxilla, long-term edentulism results in significant maxillary bone loss as well. Alveolar bone development requires the presence of teeth, and continuous stimulation is necessary to maintain it's density and volume.(Moldovan et al., 2018) However, removable dentures whether complete or partial fail to provide this stimulation and instead accelerate bone loss. Unlike natural teeth, which transmit masticatory forces throughout the bone, removable prostheses transfer force only to the bone surface, leading to reduced blood supply and total bone volume loss.(Wyatt, 1998)

This issue has long been observed but not adequately addressed by traditional dentistry. Many doctors fail to recognize or educate patients about the progressive bone loss that follows tooth extraction(D'Addazio et al., 2021). Furthermore, patients are often unaware of the anatomical changes and long-term consequences of continued bone resorption. The

problem worsens when patients wear poorly fitting soft tissue–borne prostheses, which further accelerate bone loss. Many patients only seek dental evaluation after years, when their dentures have become uncomfortable or no longer functional. Thus, traditional tooth replacement methods frequently contribute to bone loss in ways that are not adequately considered by either doctors or patients.(Müller et al., 2013)

One of the first consequences of bone loss is a decrease in bone width, which can lead to discomfort when a thin residual ridge is subjected to pressure from a removable prosthesis. Continued mandibular atrophy eventually results in prominent mylohyoid and internal oblique ridges covered by thin, mobile, and unattached mucosa, further complicating prosthetic treatment. (Kuć et al., 2017) Completely edentulous patients, bone loss leads to several significant consequences. One of the primary effects is the reduction in both the width and height of the supporting bone. As bone resorption progresses, the prominence of the mylohyoid and internal oblique ridges increases, often resulting in painful pressure points. Additionally, there is a gradual decrease in the surface area of keratinized mucosa, which further compromises oral comfort and stability.(Lee & Saponaro, 2019) As superior genial tubercles become more pronounced, painful spots develop, contributing to increased denture mobility. Muscle attachments shift closer to the crest of the ridge, leading to greater instability of the prosthesis. The contraction of the mylohyoid and buccinator muscles can cause the denture to lift, affecting posterior support. Furthermore, due to anatomical inclinations, significant bone loss alters mandibular angulation, resulting in anterior displacement of the denture.(D. Mericske-Stern et al., 2000)

3.Decreased effectiveness of removable prostheses over time

A person with natural teeth can apply an average force of 150 to 250 psi in the first molar region during occlusal movements. This force can increase up to 1000 psi during parafunctional activities. However, in edentulous patients, the maximum occlusal force drops below 50 psi. As the duration of edentulism increases, the force they can exert gradually decreases over time, negatively affecting prosthesis stability. Many patients using traditional removable dentures are unable to consume a variety of foods.. (Singhal et al., 2022) Poor chewing performance in edentulous patients can lead to digestive issues and impaired nutrient absorption. Studies show that inadequate dental function affects swallowing, increases disease risk, and may shorten lifespan. Oral health is closely linked to overall well-being, with dental disorders associated with cardiovascular diseases. Restoring proper

function in the stomatognathic system can enhance both quality of life and longevity.(Suganthi, 2018)

The use of removable partial dentures has been associated with various negative effects. Studies indicate a four-year survival rate of 60% and a ten-year survival rate of 35% for these prostheses. Over time, abutment teeth require increasing maintenance, with 60% needing repairs within five years and 80% within ten years. Additionally, patients experience greater mobility in abutment teeth, along with increased plaque accumulation, bleeding on probing, and a higher risk of caries.(Preshaw et al., 2011) Bone loss in edentulous areas progresses more rapidly due to removable prosthesis use. Research has shown that 44% of abutment teeth are lost within ten years. Given these challenges, alternative treatment options that help preserve oral health and prevent bone loss are often preferred.(Wöstmann et al., 2005)

4.Advantages of Implant-Supported Prostheses

Prostheses designed with support from implant abutments offer numerous advantages compared to traditional restorations. The primary benefit is the preservation of bone integrity and physiological continuity, as implants placed within the alveolar bone help distribute stress and load, preventing their harmful effects.

Additionally, implant-supported prostheses provide superior stability compared to removable dentures, help maintain vertical dimension, and contribute to the stabilization of occlusion. They also enhance proprioception, allowing for better sensory feedback, and significantly improve chewing efficiency. Furthermore, these restorations have greater longevity, ultimately leading to better nutrition and an improved quality of life.(Doundoulakis et al., 2003)

5.Treatment planning in implant dentistry

Implant dentistry offers highly personalized treatment plans compared to traditional prosthetic treatments. Edentulous patients seek not implants themselves but the restoration of their missing teeth. While past approaches focused primarily on bone support for implant placement, modern treatment planning prioritizes prosthetic design first. However, several additional factors influence prosthesis design. One of the fundamental principles of implant treatment is to provide the most predictable and cost-effective solution that meets both the patient's anatomical needs and personal expectations. For fully edentulous patients, removable implant-supported prostheses offer several advantages over fixed restorations. Some of the advantages of

removable implant-supported restorations include; include improved facial aesthetics, the ability to be removed at night, fewer implant requirements, lower cost, easier long-term complication management, and simpler hygiene procedures.(Tischler, 2010) However, some fully edentulous patients may require fixed prostheses due to either personal preference or their existing oral condition. For instance, if a patient has sufficient bone volume and implants have already been placed, inadequate interarch space may make a removable prosthesis unfeasible. Currently, most treatment plans for fully edentulous patients involve a maxillary complete denture (palatal prosthesis) combined with a mandibular overdenture supported by two implants. However, this approach may not be suitable for all patients, as maxillary bone resorption continues over time, and the long-term consequences of bone loss should be carefully considered. However, in partially edentulous patients, implant-supported fixed bridges are often the best solution. The psychological and functional advantages of fixed prostheses make them a preferred option. The ideal treatment plan should be tailored to the patient's existing anatomical condition and personal expectations.(Misch, 2007; Stanford, 2005)

Carl Misch defined five fundamental prosthetic options in implant dentistry in 1989.(Misch, 1989)(Table 1)

Table 1. Carl Misch's 1989 classification of prosthetic options in implant dentistry

Type	Definition
FP-1	A fixed prosthesis replaces only the crown (the upper part of the tooth) and appears just like a natural tooth.
FP-2	A fixed prosthesis replaces the crown and part of the root; while it appears normal on the occlusal (chewing) surface, it may have an elongated or prominent contour at the gingival level.
FP-3	A fixed prosthesis replaces the crowns of missing teeth, the gingival color, and part of the edentulous area. It typically includes acrylic gingiva and prosthetic teeth, but it can also be made of porcelain-metal.
RP-4	A removable prosthesis is a fully implant-supported overdenture.
RP-5	A removable prosthesis is an overdenture supported by both implants and soft tissue.

In 1989, Carl Misch defined five fundamental prosthetic options in implant dentistry. The first three options (FP-1, FP-2, FP-3) are fixed prostheses, while the last two (RP-4, RP-5) are removable prostheses. They are classified based on the amount of implant support rather than appearance. RP-4 is fully supported by implants, whereas RP-5 is supported by both implants and soft tissue.(Misch, 1989)

6.Removable Prostheses

Removable prosthetic options primarily consist of overdenture prostheses, which are classified into two main categories: fully implant-supported prostheses (RP-4) and prostheses supported by both implants and soft tissue (RP-5).(Taylor et al., 2005)

6.1.RP-4 Overdenture

This type of prosthesis is entirely supported by implants or natural teeth and provides a rigid (fixed and secure) structure when placed. A superstructure, which connects the prosthesis to the overdenture attachments, integrates the tissue bar or implant abutments into a unified system. Generally, 5-6 implants are required for the mandible and 6-8 implants for the maxilla. In removable prostheses, teeth and acrylic volume are larger, requiring implants to be positioned more lingually and deeper. In addition to implant abutments, a superstructure and overdenture attachments must be included. (Misch, 2008)

6.2.RP-5 Overdenture

RP-5 is a removable prosthesis that combines implant support with soft tissue support, resembling traditional overdenture prostheses. A fully edentulous mandibular overdenture can be supported in different ways:

1. Two independent implants in the anterior region or connected implants in the canine area → Enhances retention.
2. Three implants placed in the premolar and central incisor regions → Provides lateral stability.
3. Four implants with a bar attachment → Offers greater stability and reduces the need for soft tissue support.(Hegde, 2024)

6.2.1.Bone Resorption in RP-5 Prostheses

Since RP-5 overdentures are not fully supported by implants, alveolar bone resorption continues in soft tissue-supported areas. As a result, periodic adjustments, including relining and occlusal modifications, are necessary every few years. Bone loss in RP-5 prostheses can be two to three times greater than in conventional complete dentures.(Gowd et al., 2017)

7.Partially Edentulous Arches

Several classification systems have been proposed for partially edentulous arches, primarily to aid visualization of hard and soft tissue relationships and

facilitate communication. The Kennedy Classification is the most widely used system in clinical practice today, categorizing edentulism into four main classes:

Class I: Bilateral edentulism in the posterior region.

Class II: Unilateral edentulism in the posterior region.

Class III: A bounded edentulous space within the dental arch.

Class IV: Anterior edentulism crossing the midline.(Kuzmanovic et al., 2004)

To enhance the practical application of this system, Applegate's eight rules were introduced:

- Classification should only include natural teeth involved in the final prosthesis.
- If a tooth is planned for extraction, classification is determined based on the post-extraction condition.
- If second or third molars are not part of the restoration, they are not considered in classification.
- The most posterior edentulous area dictates the classification.

Additional edentulous areas are considered modifications and are numbered rather than measured by extent.(Kuzmanovic et al., 2004)

8.Implant Treatment Planning: Division of the Fully Edentulous Jaw

In implant treatment planning, a fully edentulous jaw is divided into specific regions. According to the Misch-Judy Classification, each region (anterior, right posterior, left posterior) is evaluated independently. Therefore, a single jaw may have one, two, or three different bone volume classifications.(Misch, 1999)

Mandible (Lower Jaw):

- Right and left posterior regions: Extend from the mental foramen to the retromolar pad.
- Anterior region: Located between the mental foramina, typically extending from premolar to premolar.

Maxilla (Upper Jaw):

- Right and left posterior regions: Typically begin in the second premolar region and are defined by maxillary sinus bone height.
- Anterior region: Located between the first premolars, positioned in front of the maxillary sinus.

Type 1: Fully Edentulous Jaw with Similar Bone Volume in All Three Regions

- When all regions have similar bone volume, the jaw is classified as Type 1.
- Type 1 is further divided into four subcategories.

Type 1, Division A: Abundant Bone Volume

- All regions contain a sufficient amount of bone volume.
- The desired number of root-form implants can be placed.
- Fully implant-supported fixed prostheses are possible.

Type 1, Division B: Sufficient but Narrow Bone Volume

- All regions have a sufficient but narrow bone volume.
- Narrow-diameter root-form implants can be used.
- In the anterior region, osteoplasty can be performed to increase bone width.
- However, if posterior bone height cannot be increased, smaller diameter implants are typically placed.

Type 1, Division C-w: Insufficient Bone Width

- Bone width is inadequate for implant placement.
- If the patient desires a removable implant-supported prosthesis, osteoplasty can convert it to C-h form.
- For a fixed prosthesis, an autogenous bone graft is required.

Type 1, Division C-h: Insufficient Bone Height

- There is not enough bone for long-term fixed implant-supported prostheses.
- Removable implant-supported prostheses (RP-4, RP-5) are generally recommended.

- The anterior region of the mandible can be treated with full subperiosteal implants.
- In some cases, root-form implants in the anterior region may support an RP-5 prosthesis.

Type 1, Division D: Severe Bone Loss

- This represents the most complex cases, where autogenous bone grafting (iliac crest) may be required.
- After six months, a total of 6-10 implants can be placed in the anterior and posterior regions.

Type 2: Different Bone Volume in the Anterior and Posterior Regions

In these cases, posterior bone volume is generally lower than in the anterior region. The classification is written with the anterior region first, as it plays the most critical role in treatment planning.

Type 2, Division A, B (Anterior A, Posterior B)

- The anterior region has abundant bone volume, while the posterior region is narrow.
- Narrow-diameter implants or bone augmentation may be considered for the posterior region.

Type 2, Division A, C (Anterior A, Posterior C)

- Abundant bone is present in the anterior region, while severe bone loss is seen in the posterior region.
- In the mandible, implants are typically placed only in the anterior region.
- In the maxilla, sinus grafting can be used to support the posterior region.
- In cases of severe posterior bone loss, the augmentation process may be prolonged.(Misch & Resnik, 2020)

9.Advantages of Implant-Supported Overdenture Prostheses Compared to Fixed Prostheses

- Since the support area is not limited to the implants, fewer implants are required.
- When there is insufficient bone, the need for bone grafting is reduced.

- Provides greater flexibility in treatment planning during implant placement.
- The soft tissue support helps restore lost facial profile support more easily.
- The positioning of the teeth on the designed prosthesis can be arranged more freely.
- Requires less technical precision during production and planning.
- Periodic implant check-ups are easier.
- Hygiene procedures are more convenient to perform.
- In patients with parafunctional habits, the ability to remove the prosthesis when necessary is an advantage.
- Repairs are much easier compared to fixed prostheses.

More cost-effective, and a fixed prosthesis can be planned in the future if needed.(Prithviraj et al., 2014)

10.Disadvantages of Implant-Supported Overdenture Prostheses

- Psychological motivation may decrease in patients who expect to use a fixed prosthesis.
- A sufficient interarch space (12–15 mm) is required.
- The intermediate connection units may need to be replaced over time.
- Since the structural components of the prosthesis are made of acrylic, repairs may be required over time.
- Due to tissue changes, the free-ending parts may require relining over time.
- Bone resorption in the posterior region can be up to three times faster in RP-5 prostheses; therefore, these prostheses should be considered temporary, and patient education should be provided accordingly.

Food retention issues.(Gray & Patel, 2021)

11.Overdenture Movement and Related Complications

The most common complications encountered in mandibular overdenture prostheses arise due to an insufficient understanding of the principles of retention, support, and stability.

Precision attachments used in overdenture prostheses have different ranges of motion (ranging from minimal movement to being relatively stable). The mobility of an overdenture varies depending on the type of attachment used and the number of existing implants. In nearly fixed prostheses, the load dynamics should resemble those of fixed prosthetic restorations.(Sadowsky, 2007)

12.Overdenture Movement Classification (PM - Prosthesis Movement)

This classification evaluates the general movement directions of the prosthesis, independent of the movement directions of the attachment components. The primary aim is to determine how much the prosthesis moves during function.

PM-0 (Non-Movable Prosthesis)

- Although the prosthesis is removable, it does not move during function.
- It is fully implant-supported and should be planned like a fixed prosthesis.

PM-2 (Movement in Two Directions - Hinge Motion)

- The prosthesis moves like a hinge (e.g., only up-down or front-back movement).
- Hader bar and Dolder bar hinge attachments are used.
- More movement may be observed, especially in the posterior regions.

PM-3 (Movement in Three Directions - Apical and Hinge Motion)

The prosthesis can move both apically (vertically) and in a hinge motion. When a Dolder bar or Hader bar is used with some space, this movement may be desirable if the ridge anatomy is weak.

PM-4 (Movement in Four Directions)

PM-5 (Multidirectional Movement)

- The prosthesis moves in multiple directions.
- Typically seen in soft tissue-supported prostheses.
- Found in types with magnetic attachments.

PM-6 (Movement in All Directions)

- The prosthesis moves completely freely.

- Implants must remain independent.
- Frequently observed in O-ring or ERA-type attachments.

Common in RP-5 prostheses.(Richter, 1989)

13.Mandıbular Implant Sıte Selectıon

The mandibular anterior region is divided into five equal vertical sections, and implant placement sites (potential areas) are labeled from right to left as A, B, C, D, and E. In mandibular implant placement, all potential sites should be evaluated with the possibility of transitioning to a fixed prosthesis in the future. For example, if implants are planned in the A, C, and E regions and the C region fails, a new implant placement can be planned in the B region. During the initial planning, if the anterior bone volume allows, implants with a diameter of 4 mm or larger are recommended in the anterior region, with modifications to the arch form for posterior support.(Prasad et al., 2013)

14.Mandibular Overdenture Treatment Options

According to Carl E. Misch's treatment protocol, five different treatment options are available for mandibular overdenture therapy. Each option is determined based on factors such as bone volume, prosthesis stability, and cost.(Table 2)(Lambade et al., 2014)

Table 2. Mandibular Overdenture Treatment Options

Option	Description	İmplant Positions	Prosthesis Movements (PM)	Indication
OD-1	RP-5 with Independent Implants in B and D Positions	B - D	PM-6	Cost
OD-2	Implants in B and D Positions Connected by a Rigid Bar	B - D	PM-3 – PM-6	More Stability, Cost Still Matters
OD-3A	Implants in A, C, and E Positions	A - C - E	PM-2 – PM-6	Ideal Posterior Bone Form, Moderate Stability
OD-3B	Implants in B, C, and D Positions (if posterior bone form is poor)	B - C - D	PM-3 – PM-6	Weak Posterior Bone, Moderate Stability
OD-4	Implants in A, B, D, and E Positions with a Rigid Bar and a 10 mm Distal Cantilever	A - B - D - E	PM-2 – PM-6	More Support

Table 2. Mandibular Overdenture Treatment Options

Option	Description	Implant Positions	Prosthesis Movements (PM)	Indication
OD-5	Implants in A, B, C, D, and E Positions with a Rigid Bar and a 15 mm Distal Cantilever	A - B - C - D - E	PM-0	Maximum Stability, Support, and Comfort

If Cost is a Concern:

- OD-1 or OD-2 should be considered.
- OD-3A is suitable if the posterior bone is sufficient and moderate stability is desired.
- OD-3B is preferable if the posterior bone is weak but high stability is needed.
- OD-4 provides greater support and stability.

OD-5 ensures maximum support, stability, and comfort and should be evaluated for prosthetic indication.(Lambade et al., 2014)

15.Overdenture Attachment Systems

O-Ring or Ball Attachments

The O-ring attachment is one of the most widely used stud attachments in dentistry, enhancing retention in implant-supported complete and partial overdentures as well as conventional overdentures. The O-ring abutment has a ball-shaped head that connects to a post or cuff (patrix), with a groove or undercut area (matrix) to hold the O-ring. Typically made from titanium alloy, the O-ring abutment is either screwed directly into the implant or cast into a precious or semi-precious alloy superstructure bar.(ELsyad et al., 2018)

Advantages of o-ring attachments

1. Flexibility and Durability: Allows slight movement of the prosthesis while maintaining strong retention.
2. Self-Aligning Feature: The material's elasticity compensates for minor misalignments, improving fit.
3. Easy Maintenance and Replacement: The retentive component inside the prosthesis can be replaced without altering the implant or bar. (Ohkubo et al., 2004)

Single attachment systems in ımplant-supported overdenture prostheses

o-ring size

The diameter of the O-ring depends on the available space within the overdenture acrylic:

- Larger O-rings provide greater retention, ease of use, and reduced complications.
- Available in three standard sizes.
- The inner diameter is slightly smaller than the retentive post to ensure a secure grip.
- Hardness is measured on the Shore A scale:
  - Softest O-rings: 30-40 Shore A
  - Hardest O-rings: 80-90 Shore A
- Color does not indicate hardness. While black is common, some manufacturers use different colors for standardization or aesthetics.

Materials used: Silicone, nitrile, fluorocarbon (Viton), and ethylene-propylene (EPDM).(Qin et al., 2019)

Locator attachment system

The Locator attachment system consists of a patrix, which is screwed into implants at different heights, and a matrix, which is a replaceable nylon component housed within a metal cap inside the prosthesis. These nylon matrices come in different colors, each representing a specific retention value. This system is particularly suitable for cases with limited interocclusal space and implant angulations of up to 40°.

The Locator system includes abutments compatible with all implant diameters, a metal housing containing a black processing cap (Locator Processing Cap), and interchangeable nylon inserts (Locator Inserts) available in blue, pink, clear, red, orange, and green, each offering different levels of retention.(Miler et al., 2017)

The OD-secure attachment

Compensates for implant angulations up to 30°, while the Xtend housing allows for corrections up to 50°. Its patrix surfaces are coated with titanium nitride for enhanced wear resistance. Designed with a low-profile structure, it has a height of 2 mm.(Midentistry, 2021)

The Locator R-TX system

The Locator R-TX system tolerates implant angulations up to 60° and features a DuraTec coating for increased hardness and wear resistance. Its narrower cavity reduces plaque buildup, and its dual retention surfaces enhance stability. The pink housing includes horizontal grooves for improved prosthetic fixation.(Chavez, 2021)

The optiloc system

Features an ADLC (Amorphous Diamond-Like Carbon) coating, enhancing wear resistance. Its retentive insert is made of PEEK material and accommodates implant angulations up to 40°. Unlike other matrix systems, it allows minimal prosthetic movement without dislodging and always returns to its original position.(Arul & Jebaselvi, 2024)

The locator F-TX system

Is designed for fixed full-arch restorations. Unlike traditional fixed restorations, it does not require cement or screws, relying on a passive fit connection. It provides a removable option for clinicians while remaining fixed for the patient, ensuring aesthetics, cost efficiency, and enhanced comfort.(Amato & Polara, 2018)

The CM-Loc system

Features an abutment without a central retention hole, improving cleanliness. Its retentive insert, made of wear-resistant Pekkton polymer, allows for implant angulations up to 60°.(Naguib et al., 2019)

The locator root attachment system

Utilizes natural tooth roots to retain overdentures or partial prostheses, offering an aesthetic and stable solution for patients who cannot afford implants. It serves as an interim step before implant treatment, helping to preserve bone, maintain facial profile, and support future implant success. Available in straight, 10°, and 20° options, it is suitable for divergent roots. (Miler et al., 2017)

The novaloc system

Ensures retention through a snap-fit mechanical locking mechanism. Its titanium abutment is reinforced with a diamond-like carbon coating, while the matrix is made of PEEK. Designed to tolerate implant angulations up to 40°, it offers enhanced wear resistance. The retentive ring, made of flexible PEEK, comes in different colors based on retention levels and allows slight flexing during insertion and removal.(Szeluga et al., 2008)

The saturno narrow-diameter implant system

Features a straight or 20°-angled O-ball attachment with a micro O-ring for retention. It accommodates implant angulations up to 30.

Hader Bar and Clip System

Introduced by Helmut Hader in the late 1960s, the system was 8.3 mm in height. Today, Hader bar systems are designed with a height of only 3 mm, offering three different retention types for greater flexibility. Compared to O-ring systems, Hader bars allow for a lower-profile prosthetic design. Hader bar overdentures can be designed with a height of 4 mm, whereas O-ring overdentures require at least 5-7 mm, making the Hader bar system more stable and retentive. The cantilever length should be carefully adjusted and should not exceed 10-12 mm.(Singh et al., 2013)

Implant-Supported Overdenture Prostheses and Treatment Approach

If only two implants are used for edentulous mandibular restoration, both should not be positioned anterior to the mental foramen.

Five treatment options are available for mandibular implant-supported overdentures, standardized for patients with Division A anterior bone but modified for Division C-h bone as follows:

- An additional implant is added to each treatment option.
- OD-1 is completely removed.
- OD-2: Applied with three implants (B, C, D).
- OD-3: Applied with four implants (A, B, D, E).
- OD-4: Applied with five implants (A, B, C, D, E).

OD-5: Applied with six implants.(Kuoppala et al., 2012)

16.Regional Limitations for Partial Edentulism in the Anterior Maxilla

Implant placement in the maxilla is more complex due to bone resorption, low bone density, and biomechanical challenges. Treatment planning should consider bone grafting, appropriate implant diameter, and positioning. Narrow ridges require narrow implants, which increase stress concentration. Facial cantilevers may cause excessive moment loads, and off-axis occlusal forces can lead to overloading. Low bone density reduces implant support, while palatal bone resorption patterns make implant placement more difficult.(Krennmair et al., 2011)

17.Treatment Options for Partially Edentulous Patients in the Anterior Maxilla

1. Traditional Tooth-Supported Bridge: A practical, low-risk, and cost-effective option but unsuitable for long edentulous spans. It requires tooth preparation and is not ideal for weak abutment teeth.
2. Traditional Removable Partial Denture: While cost-effective, it is the least preferred due to aesthetic concerns and patient discomfort. It may cause rapid deterioration of abutment teeth and basal bone.
3. Resin-Bonded Bridge (Maryland Bridge): A conservative approach with minimal tooth reduction, but unsuitable for large edentulous areas.
4. Implant-Supported Fixed Prosthesis: The most preferred option as it preserves alveolar bone stimulation, requires no preparation of adjacent teeth, and offers long-term success.(Arita et al., 2020)

18.Maxillary Overdenture Options

Maxillary complete dentures are generally better tolerated than mandibular ones. Patients often focus on mandibular restorations first, but after receiving a mandibular implant-supported prosthesis, they frequently seek maxillary implant treatment. However, implant failure rates in maxillary overdentures are higher than in mandibular overdentures. While mandibular implant overdentures offer five treatment options, maxillary overdentures provide only two due to:

- Biomechanical disadvantages of the maxillary bone

Lower bone density and unfavorable force distribution affecting implant stability.(Osman et al., 2012)

19.Maxillary Overdenture Treatment Options

RP-5

- Includes partial posterior soft tissue support
- Supported by both soft tissue and implants
- Requires fewer implants
- Minimum 4 implants required, at least 3 in the premaxillary region
- Key implant sites: Bilateral canine regions, ideally one central incisor, or alternatively bilateral lateral incisors and first premolar areas

- Antero-posterior (AP) spread should be maximized

RP-4

- Fully implant-supported, retained, and stabilized prosthesis
- No soft tissue support
- Requires more implants (typically 6 or more)

Provides greater biomechanical stability(Osman et al., 2012)

20.Biomechanics of Maxillary Overdentures

- Cantilever bars are not recommended due to poor bone quality and excessive load risks.
- Implants should not be placed independently; they must be splinted with a rigid bar.
- AP spread should be maximized.
- Minimum bone height: 15 mm in the anterior, 12 mm in the posterior.
- Bar should be slightly lingual to the original crest and not extend posteriorly.

The prosthesis must allow movement in at least two directions.(Gibreel et al., 2019)

21.Maxillary Overdenture Attachment Options

Hader Clip (for RP-5 Prosthetic Restorations)

- Provides a more rigid structure, functioning similarly to a fixed restoration supporting all 14 teeth.
- Positioned centrally along the midline of the arch.
- A small gap must be left distal to the implant to allow posterior soft tissue movement.
- The prosthesis should extend to cover the tuberosities and A-line, similar to a complete denture design.

O-Ring Attachments

- Positioned more distally than Hader clips, usually just distal to the canine region.
- This allows slight rotation around a fulcrum in the canine or premolar area.

RP-5 Prosthesis Design

- Uses 7 to 10 implants, making it a fully implant-supported and rigid system.
- Functions similarly to a fixed prosthesis but may require a labial flange or bone grafting in the premaxilla due to bone resorption.
- Preserves more bone volume and provides greater stability and security.
- Key implant positions:
  - Bilateral canine regions
  - Distal half of the first molar region
  - Bilateral second premolar regions

At least one anterior implant, typically in the central incisor region(Sutariya et al., 2021)

22.Prosthesis Design and Occlusion

- Implants must be splinted with a rigid bar.
- At least four attachments should be used along the arch.
- The palatal region is usually covered with acrylic.
  - Removing palatal coverage may cause food entrapment and speech issues.

However, special cases (e.g., strong gag reflex, frequent speakers, new denture users) should be evaluated individually.(Sutariya et al., 2021)

23.Clinical Application and Advantages

- If the central incisor region lacks sufficient bone, alternative implant sites can be used.
- Implant diameter should be at least 5 mm to ensure stability.
- In patients with severe premaxillary bone loss, overdentures provide a reliable support structure.(Mirchandani et al., 2021)

24.Occlusion of implant-supported prostheses

In the selection of occlusion in implant-supported prostheses, the following factors should be considered:

- Number of implants

- Load
- Occlusion of the opposing jaw
- Restorative material used in the opposing jaw
- Parafunctional habits
- Existing type of occlusion
- Occlusal plane
- Interalveolar distance
- Dental anamnesis

There are three fundamental principles of occlusion in implant-supported prostheses: increasing the support areas of the prosthesis, regulating the direction of forces, and reducing the amount of force applied to the prosthesis.(Rocha et al., 2023)

25.Occlusion in implant-supported removable prostheses

If the opposing jaw is edentulous, a mandibular overdenture supported by two implants would be a more suitable treatment plan when a flexible attachment that allows movement is used. In patients planned for a mucosa-supported conventional prosthesis in the maxilla, a mucosa-implant-supported prosthesis and bilateral balanced occlusion are recommended for the mandible.For overdentures in patients with a normal ridge, bilateral balanced lingualized occlusion is advised.In cases of severely resorbed ridges, monoplane occlusion should be used. Occlusal planning should be designed according to the type of edentulism, as shown in the table 3.(Table 3)(LORD & TEEL, 1969)

Table 3. Occlusal planning should be designed according to the type of edentulism

Edentulism	Type of prosthesis	Type of occlusion
Complete edentulism	Fixed prosthesis	Canine-guided occlusion
Complete edentulism	overdenture	Bilateral balanced occlusion
Kennedy III and IV	Implant-supported fixed prosthesis	Unilateral balanced occlusion
Kennedy I and II	Implant-supported fixed prosthesis	Canine-guided occlusion

Determining the ideal occlusion type for implant-supported prostheses with a single rule would be misleading.Therefore, each case should be evaluated individually, considering: Dentition of the opposing jaw, prosthetic material, number of implants used and localization of the implants. Based

on these factors, the appropriate occlusion type should be determined. Implant-protective occlusion is an approach aimed at ensuring the long-term success of implant-supported prostheses by distributing occlusal forces in a balanced manner. Unlike natural teeth, implants do not have periodontal ligaments; therefore, traditional occlusion principles cannot be directly applied to implants.(Abichandani et al., 2013)

26.Immediate Load Applications in implant dentistry

Immediate loading is a treatment approach that involves placing a temporary or permanent prosthesis immediately after the surgical placement of the implant. Traditionally, the two-stage surgical protocol developed by Brånemark requires a waiting period of 3 to 6 months for the implant to achieve osseointegration with the bone. In contrast, the immediate loading protocol aims to put the implant into function immediately or within a very short period. Immediate Loading and Implant Maintenance.(Misch & Scortecci, 2005)

27.Immediate Loading Requirements

For immediate loading to be performed, primary stability must be achieved at a torque force of 35 Ncm.

Advantages of Immediate Loading

- Faster treatment process
- No need for a second surgical procedure
- Better preservation of soft tissue form
- Psychological benefits by preventing an edentulous period for the patient

Disadvantages and Risks of Immediate Loading

- Higher risk of complications if primary stability is insufficient
- Micro-movements must be controlled within acceptable limits

Higher failure rates compared to traditional protocols(Tettamanti et al., 2017)

Immediate Loading in Partially Edentulous Patients

The immediate loading concept can also be applied to partially edentulous patients and single-tooth implants. However, due to frequent occlusal contact with opposing teeth, temporary restorations should be carefully designed.

Most clinical studies indicate similar implant survival rates between immediate loading and the submerged two-stage healing protocol. However, this does not mean immediate loading is suitable for all patients. Following biomechanical principles during immediate loading procedures significantly improves implant success.(Huynh-Ba et al., 2018)

28.Dental Implant Maintenance

Regular care and hygiene are essential for the long-term success of dental implants. Patients must attend routine dental check-ups based on their oral hygiene, number of implants, and overall health status:

- First 6 months: Every 1 to 3 months
- Between 1–2 years: Every 6 months

After 2 years: Annually(Humphrey, 2006)

During dental examinations:

- Bone and gum health around the implant should be evaluated
- Radiographic control should be performed
- Occlusion assessment should be conducted

At home, patients should be educated on proper flossing and brushing techniques. Overdenture prostheses should be removed and cleaned every night, using special prosthesis cleaning solutions.(Chen & Darby, 2003)

29.Criteria for Evaluating Bone Loss Around Implants

For an implant to be considered in ideal health:

- Bone loss should be less than 1.5 mm in the first year
- Less than 1.0 mm of bone loss should occur after prosthetic loading
- No exudate (pus) or radiolucent areas (bone loss regions) should be present
- No vertical mobility should be observed
- Periodontal pocket depth should be less than 2.5 mm

Lamina dura (bone border) should remain intact(Galindo-Moreno et al., 2015)

30.Types and Stages of Implant Failure

1. Surgical Failure: Caused by incorrect implant positioning or damage to bone integrity.
2. Failure During Healing: Results from infection, poor bone quality, or implant mobility, leading to loss of stability.
3. Early Loading Failure (within the first year): Occurs due to incorrect prosthetic positioning, excessive occlusal load, or infection, preventing proper osseointegration.
4. Medium-term (up to 5 years) and Late-stage (5–10 years) Failures: Develop due to long-term excessive loading, poor hygiene, or progressive bone loss, leading to implant instability.(Mohajerani et al., 2017)

To prevent implant failure, surgical planning, appropriate loading protocols, and regular maintenance are crucial. Identifying the failure stage and cause enables the implementation of an effective treatment plan, reducing peri-implant diseases and increasing implant success.(Rosenberg et al., 2004)

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