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FACTORS AFFECTING THE SUCCESS OF DENTAL IMPLANT TREATMENTS

DENTAL İMPLANT TEDAVİLERİNİN BAŞARISINI ETKİLEYEN FAKTÖRLER

Recep KARA[1]

[1] Private Dental Clinic, Kütahya/Türkiye,

ORCID ID: 0000-0002-6447-4972

Corresponding Author:

Recep KARA,

Özel Diş Kliniği, Kütahya/Türkiye

e-mail: *drecepkara@gmail.com*

Abstract

Dental implant treatment has emerged as a reliable method for replacing missing teeth and restoring oral function and aesthetics. Its success, however, is multifactorial and dependent on systemic, local, and procedural conditions. Patient-related variables such as systemic health, bone quality, and oral hygiene habits play critical roles, as do surgical protocols and implant materials' properties. One of the primary goals in implant dentistry is achieving and maintaining osseointegration—a direct connection between the implant and the surrounding bone tissue. Various risk factors, including smoking and metabolic disorders like diabetes mellitus, can compromise this process and lead to implant failure. A comprehensive understanding of these factors is vital for clinicians to develop individualized treatment plans and improve long-term outcomes.

This study involved a literature review of peer-reviewed articles and clinical studies published in the last few years, focusing on factors affecting the success and longevity of dental implants. Databases such as PubMed, Scopus, and Google Scholar were searched using keywords like "dental implant," "osseointegration," "bone density," "implant failure," and "biocompatibility." Inclusion criteria included clinical trials, meta-analyses, and systematic reviews discussing implant-related risk factors and their management. Data were analyzed qualitatively to identify common themes and evidence-based strategies for improving implant survival.

The findings indicate that high bone density, meticulous surgical technique, and good oral hygiene significantly contribute to successful osseointegration and implant survival. Conversely, risk factors such as smoking, uncontrolled diabetes, and poor post-operative care are strongly associated with higher implant failure rates. Biocompatible materials, particularly titanium, and its alloys, showed superior integration with surrounding bone. Additionally, proper patient selection and individualized treatment planning were emphasized as essential for predictable outcomes.

Dental implant therapy is a predictable and effective modality for oral rehabilitation when critical biological, mechanical, and lifestyle factors are carefully considered. Understanding the interaction between systemic health, local bone conditions, surgical procedures, and patient habits enables clinicians to reduce complications and increase the long-term success of implants. Future research should continue exploring personalized treatment strategies and implant materials innovations to enhance clinical outcomes.

Keywords: *Dental implant, Bone density, Osseointegration, Implant failure, Biocompatibility, Surgical techniques.*

Özet

Diş implantı tedavisi, eksik dişlerin yerini doldurmak ve ağız fonksiyonunu ve estetiğini geri kazandırmak için güvenilir bir yöntem olarak ortaya çıkmıştır. Ancak başarısı çok faktörlüdür ve sistemik, lokal ve prosedürel koşullara bağlıdır. Sistemik sağlık, kemik kalitesi ve ağız hijyeni alışkanlıkları gibi hasta ile ilgili değişkenler, cerrahi protokoller ve implant malzemelerinin özellikleri gibi kritik roller oynar. İmplant diş hekimliğindeki temel hedeflerden biri, implant ile çevresindeki kemik dokusu arasında doğrudan bir bağlantı olan osseointegrasyonu sağlamak ve sürdürmektir. Sigara içmek ve diabetes mellitus gibi metabolik bozukluklar da dahil olmak üzere çeşitli risk faktörleri bu süreci tehlikeye atabilir ve implant başarısızlığına yol açabilir. Bu faktörlerin kapsamlı bir şekilde anlaşılması, kişiselleştirilmiş tedavi planları geliştirmek ve uzun vadeli sonuçları iyileştirmek için hayati önem taşır.

Bu çalışma, son birkaç yılda yayınlanmış hakemli makalelerin ve klinik çalışmaların literatür incelemesini içermekte olup, dental implantların başarısını ve uzun ömürlülüğünü etkileyen faktörlere odaklanmaktadır. PubMed, Scopus ve Google Scholar gibi veri tabanları, "dental implant", "osseointegrasyon", "kemik yoğunluğu", "implant başarısızlığı" ve "biyouyumluluk" gibi anahtar kelimeler kullanılarak aranmıştır. Dahil etme kriterleri arasında klinik çalışmalar, meta analizler ve implantla ilişkili risk faktörlerini ve bunların yönetimini ele alan sistematik derlemeler yer almıştır. Veriler, implant sağkalımını iyileştirmek için ortak temaları ve kanıta dayalı stratejileri belirlemek amacıyla nitel olarak analiz edilmiştir.

Bulgular, yüksek kemik yoğunluğunun, titiz cerrahi tekniğin ve iyi ağız hijyeninin başarılı osseointegrasyona ve implant sağkalımına önemli ölçüde katkıda bulunduğunu göstermektedir. Tersine, sigara içme, kontrolsüz diyabet ve yetersiz postoperatif bakım gibi risk faktörleri, daha yüksek implant başarısızlık oranlarıyla güçlü bir şekilde ilişkilidir. Biyouyumlu malzemeler, özellikle titanyum ve alaşımları, çevredeki kemikle üstün entegrasyon göstermiştir. Ek olarak, uygun hasta seçimi ve kişiselleştirilmiş tedavi planlamasının öngörülebilir sonuçlar için gerekli olduğu vurgulanmıştır.

Diş implantı tedavisi, kritik biyolojik, mekanik ve yaşam tarzı faktörleri dikkatlice değerlendirildiğinde oral rehabilitasyon için öngörülebilir ve etkili bir yöntemdir. Sistemik sağlık, lokal kemik koşulları, cerrahi prosedürler ve hasta alışkanlıkları arasındaki etkileşimi anlamak, klinisyenlerin komplikasyonları azaltmasını ve implantların uzun vadeli başarısını artırmasını sağlar. Gelecekteki araştırmalar, klinik sonuçları iyileştirmek için kişiselleştirilmiş tedavi stratejilerini ve implant malzemesi yeniliklerini keşfetmeye devam etmelidir.

Anahtar Kelimeler: *Diş implantı, Kemik yoğunluğu, Osseointegrasyon, İmplant başarısızlığı, Biyouyumluluk, Cerrahi teknikler.*

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OVERVIEW / GENEL BAKIŞ

1. Bone Quality and Quantity

1.1. Anatomical and Biological Features of Bone Structure

1.1.1. Anatomical Features

1.1.1.1. Bone Density and Types

The bone used in the placement of dental implants is primarily divided into two main structures:

- **Cortical Bone:** Cortical bone has high density and low vascularity and is important in ensuring implant stability. However, low vascularity may prolong the healing process [1].
- **Trabecular Bone:** Trabecular bone, which has a lower density, offers faster healing potential due to its high vascularity but is disadvantageous in primary stability [2].

Bone density is classified into four types according to the classification of Lekholm and Zarb (Figure 1A) [3]:

Type D1: Very dense cortical bone. Typically found in the anterior mandible and offers high primary stability.

Type D2: Bone that is a mixture of cortical and trabecular bone. Provides a balanced structure for ideal osseointegration.

Type D3: Predominantly trabecular bone. It offers less stability but has a faster healing process.

Type D4: Low-density trabecular bone. It is typically seen in older patients in the posterior maxilla and usually requires bone augmentation [4].

Implant success rates are higher in D1 and D2-type bone structures. However, there is a higher risk of complications in D3 and D4-type bones due to insufficient stability [1].

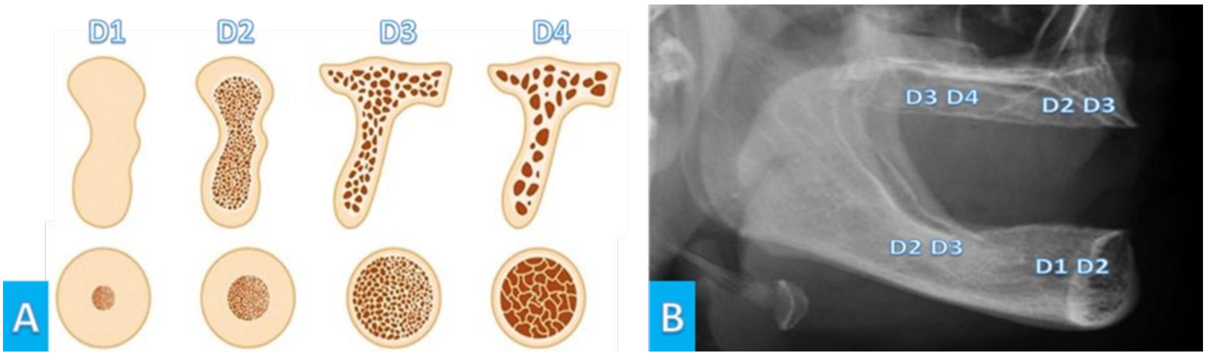

Figure 1: (A) Presentation of the four types of bone density. (B) Presentation of the possible different bone density types on jaws.

1.1.1.2. Differences between the Maxilla and Mandible

The maxilla generally has a less dense bone structure compared to the mandible. Therefore, longer and broader diameter implants may be required to achieve primary stability in the maxilla. In contrast, the mandible typically offers better stability due to its denser cortical bone structure (Figure 1B).

1.1.1.3. Anatomical Structures

In dental implant procedures, paying attention to anatomical structures is vital. Localizing nerve tissues, such as the inferior alveolar nerve and mental nerve, and maxillary sinuses plays a critical role in implant planning. Implants placed in incorrect positions can lead to serious complications such as nerve injuries or sinus perforations [5].

1.1.2. Biological Characteristics

1.1.2.1. Bone Remodeling

The process of osseointegration depends on the biological capacity of the bone structure. Wolff’s Law describes the ability of bone to adapt to mechanical stresses. After the placement of a dental implant, stress distribution occurs in the bone and stimulates the formation of new bone tissue [6].

1.1.2.2. Vascularization

Blood flow to bone tissue directly affects the healing process and osseointegration. Implant success rates are reduced, especially in areas with reduced blood circulation due to trauma or infection [7].

1.1.2.3. Systemic Factors

Bone structure is affected by an individual's general health, age, and metabolic diseases. Conditions such as osteoporosis or diabetes can reduce bone quality and negatively impact implant success [8].

In dental implant treatment, the anatomical and biological characteristics of the bone structure are of fundamental importance for treatment planning and success. The individual bone structure of patients should be carefully evaluated, and appropriate treatment strategies should be developed. In this context, anatomical and biological factors can be optimized with a multidisciplinary approach, and success rates can be increased.

1.2. Bone Quantity: The Importance of Width and Height

Bone width and height are critical factors in planning dental implant treatment. Inadequate bone width and height can negatively affect the primary stability of the implant and may lead to complications such as peri-implantitis. While width affects the compatibility of the implant with the cortical bone, height is necessary for adequate implant length [9]. In cases of insufficient bone height, especially in the posterior maxilla, advanced surgical procedures such as sinus lifting may be required.

The amount of bone directly affects the success of implant placement:

- **Bone Width:** A minimum of 1–2 mm of cortical bone thickness is required around the implant. This optimizes stress distribution around the implant and prevents bone loss [10].
- **Bone Height:** Inadequate bone height may require surgical procedures such as sinus lift or vertical bone grafting [2].

1.3. Primary Stability and Osseointegration

Primary stability refers to the mechanical stability of the implant at the time of placement and is dependent mainly on bone density. The success of primary stability is critical to the osseointegration process [1].

Factors affecting primary stability include bone density and type, implant design and surface properties, and surgical technique [4].

1.3.1. Primary Stability

Primary stability refers to the mechanical stability of a dental implant at the time of placement and is the first step to implant success. This stability is achieved by the implant's attachment to the bone and is affected by factors such as bone density, implant surface, design, and surgical technique [11]. High primary stability supports the healing process by reducing the risk of implant movement.

1.3.2. Osseointegration

Osseointegration is the formation of a direct biological connection between the dental implant and the bone. This process ensures bone remodeling and biomechanical stability of the implant. Brånemark emphasized that osseointegration is essential for the long-term success of implant treatment [10].

1.3.3. Relationship Between Primary Stability and Osseointegration

Primary stability is essential for the beginning of the osseointegration process. Inadequate primary stability can cause micromovements of the implant and compromise osseointegration. Therefore, ensuring optimal stability during implant placement is critical [8].

1.4. Bone Regeneration Techniques

In dental implant treatment, insufficient bone amount can negatively affect the success of treatment. Therefore, bone regeneration techniques are important, especially in patients with insufficient bone width and height.

1.4.1. Autogenous Grafts

Autogenous grafts are methods that use tissues taken from the patient's own bone. This technique is considered the gold standard due to its high biocompatibility and bone regeneration potential [12].

1.4.2. Allografts and Xenografts

Allografts are bone materials obtained from human donors, while xenografts are obtained from animal sources. These grafts require less surgery than autogenous grafts, but their healing process can be longer [13,9].

1.4.3. Regenerative Biomaterials

Regenerative biomaterials such as platelet-rich plasma and platelet-rich fibrin contain growth factors that accelerate healing. These materials are combined with bone grafts to facilitate the osseointegration process [14].

1.4.4. Guided Bone Regeneration

Guided bone regeneration allows bone tissue to regenerate in a specific area using biological barriers. This technique increases the amount of bone and prepares a suitable ground for implant placement [2,15].

1.5. Effect of Bone Factor on Clinical Success

Bone properties have a direct impact on clinical success by affecting the primary stability and osseointegration of the implant. High-density cortical bone provides a more suitable environment for primary stability. Bone resorption should be minimal during the healing period [1].

2. Patient-Related Factors

Several patient-specific factors influence the success of dental implants.

2.1. Systemic Health Condition

The patient's general health status plays a vital role in the success of implant treatment.

- **Diabetes Mellitus:** Uncontrolled diabetes slows wound healing and increases the risk of infection [1]. Implant success in patients with controlled diabetes may be similar to that of the general population [2].
- **Osteoporosis:** Low bone density may reduce implant stability [4]. The risk of jaw osteonecrosis should be considered in patients receiving bisphosphonate therapy.
- **Immune System Diseases:** The risk of infection may be increased in patients taking corticosteroids or immunosuppressants [9].
- **Cardiovascular Diseases:** Special planning is required for preoperative bleeding control in patients receiving anticoagulant therapy.

2.2. Lifestyle Factors

- **Smoking:** Nicotine reduces blood flow to the tissues around the implant and reduces the success of osseointegration [2]. The risk of peri-implantitis is higher in patients who smoke [2].
- **Alcohol Consumption:** Excessive alcohol consumption may negatively affect bone regeneration and wound healing [1].
- **Stress and Psychological Factors:** Stress can slow down the healing process by affecting the immune system response.

2.3. Oral Hygiene Habits

- **Poor Oral Hygiene:** Inadequate oral hygiene increases the risk of peri-implantitis and implant loss [4]. Regular professional cleaning and patient education are critical to the long-term success of the implant.
- **Periodontal Status:** Patients with a history of periodontal disease are at higher risk of peri-implant disease [2].

2.4. Age and Gender

- **Age:** Bone density and vascularity may decrease in older patients, affecting healing [9]. Age is a complex variable that can affect the outcomes of implant treatment. It has been shown that with advanced age, a decrease in bone mineral density and, depending on bone quality, a reduction in implant stability may occur [52]. However, systematic analyses report that advanced age alone does not significantly reduce implant success [53]. Factors that play a decisive role in success include systemic health status, bone quality and volume, and patient compliance [54]. Age should not be considered a risk factor on its own; each patient should be evaluated individually.
- **Gender:** In women, especially postmenopausal women, decreased bone density may affect implant success [1].

2.5. Jaw and Bone Condition

- **Bone Quality and Quantity:** Patients with insufficient bone volume or low bone density may require bone augmentation [2].
- **Bruxism:** Bruxism can overload implants, leading to implant failure [4].

2.6. Patient Compliance and Education

- **Patient Adaptation:** The success of implant treatment depends on the patient's compliance with instructions [9]. The risk of complications increases in patients who do not attend regular check-up appointments.
- **Patient Education:** The importance of implant care and oral hygiene techniques should be explained to the patient in detail.

3. Surgical Technique

The skill of the clinician and the techniques used during surgery directly affect implant outcomes.

3.1. Types of Surgical Techniques

Surgical techniques used during dental implant placement are generally classified according to the method and timing of implant placement.

- **Single-Stage Surgery:** Once the implant is placed, the healing cap is immediately attached, eliminating the need for a second surgery. The healing process is faster due to less soft tissue manipulation [1].
- **Two-Stage Surgery:** The implant is placed under the soft tissue and opened after a second surgery once osseointegration is completed. This technique provides longer-term stability and infection protection [2].

- **Immediate Placement:** Implants are placed immediately after tooth extraction. This approach prevents bone resorption but requires high primary stability [2].
- **Delayed Placement:** After extraction, the implant is placed after the bone and soft tissues have completely healed.

3.2. Preparation of the Surgical Region

- **Sterilization and Aseptic Conditions:** It is critical that the surgical field is sterile to minimize the risk of infection [1].
- **Preparation of the Bone Socket:** Correct sizing and exposure of the bone bed increase implant stability. Preparation with high speed and low heat production prevents necrotic bone formation.
- **Liquid Cooling During Surgery:** Adequate cooling during surgery prevents thermal damage to bone tissue [16].

3.3. Placement of the Implant

- **Torque Application:** Optimal insertion torque should generally be between 35 and 45 Ncm. Too low torque reduces stability, while excessive torque can cause bone microfractures [1].
- **Position and Angle of the Implant:** The angle of the implant should distribute chewing forces evenly. Incorrect positioning increases the risk of biomechanical stress and peri-implantitis [9].
- **Subcrestal or Crestal Placement:** Subcrestal placement provides better results in esthetic areas but requires careful planning to reduce the risk of peri-implantitis [2].

3.4. Loading Protocols

- **Immediate Loading:** Prosthesis loading is done immediately after implant placement. It is preferred in cases where primary stability is high. It provides faster functional and esthetic results but has a higher risk of failure [1].
- **Early Loading:** Loading is done within 4–8 weeks after implant placement. Loading should be done carefully while the osseointegration process continues [9].
- **Late Loading:** The prosthesis is loaded once osseointegration is complete, usually after 3–6 months. This protocol minimizes the risk of complications.

3.5. Complications and Prevention

- **Thermal Damage:** High temperature greater than 47°C can cause bone necrosis. Appropriate rapid cooling should be applied to avoid thermal damage [16].
- **Surgical Stress and Microcracks:** Excessive torque or improper placement may cause microfractures in the bone and affect osseointegration.

- **Peri-implantitis:** Inadequate sterilization or lack of post-surgical hygiene may increase the risk of peri-implantitis [2].

3.6. New Technologies and Approaches

- **Flapless Surgery:** The implant is placed without a soft tissue incision. Since it is a less invasive approach, recovery time is shortened. However, proper patient selection is critical [9].
- **Digital Surgical Guides:** Failure rates can be reduced and precision increased by using digital guides during implant placement [1].

4. Implant Design and Surface Modifications

Implant characteristics play a crucial role in achieving stability and osseointegration.

4.1. Implant Design

The implant's shape, size, and geometry affect its primary stability and biomechanical performance.

- **Cylindrical Implants:** These implants require a less invasive surgical procedure and are primarily used in soft bone [1].
- **Conical Implants:** The cone-shaped design increases primary stability with a compression effect. These implants are especially preferred in low-density bones [2].
- **Implant Diameter and Length:** Large-diameter implants provide more contact surface, increasing stability. However, mini implants can be used in narrow jawbones [9]. Longer implants provide more surface area, improving osseointegration. However, short implants can be used in cases where bone height is limited.
- **Thread Design of the Implant:** The inclination, width, and depth of the threads affect the contact surface of the implant with the bone. Sharp threads provide better stability in hard bones [4]. Wide threads increase stability by creating a compression effect on soft bones.

4.2. Implant Surface Properties

Dental implants are biomaterials widely used in the treatment of tooth loss. The success rate of these implants depends mainly on the implant surface properties. Properties such as surface topography, roughness level, chemical composition, and hydrophilicity can affect the osseointegration process and long-term implant stability. Literature reviews and clinical study findings reveal the importance of implant surface modifications on treatment success [5].

The implant surface should be designed to increase the contact of bone cells with the implant and osseointegration.

- **Surface Topography:** The surface topography of dental implants, referring to their micro- and nano-scale structure, plays a crucial role in osseointegration. Moderate surface roughness, such as Sa 1–2 μm, has been shown to enhance osteoblast activity and accelerate bone integration with the implant surface [17].
- **Polished Surfaces:** These surfaces exhibit lower plaque accumulation and reduced risk of peri-implantitis, but they generally have a slower osseointegration rate compared to roughened surfaces [1]. Smooth surfaces are typically used in areas where minimizing bacterial colonization is prioritized rather than for enhanced bone anchorage [23].
- **Micro-rough Surfaces:** These surfaces increase the adhesion of osteoblast cells to the surface and promote bone formation [2].
- **Sandblasting and Acid Etching:** Sandblasting and etching techniques create micro- and nanostructures on implant surfaces, facilitating the adhesion of bone tissue to the surface. These techniques are widely used to accelerate osseointegration and increase stability. They add micro- and nano-roughness to the surface, increasing the contact rate with the bone [9].
- **Titanium Plasma Spray Coating:** This treatment expands the surface area and increases osteoblast activity [18].
- **Hydroxyapatite Coating:** Hydroxyapatite coating supports bone regeneration by adding a highly biocompatible material to the implant surface. However, the coating's durability and long-term biological behavior are critical factors affecting success [17]. Hydroxyapatite coating increases biocompatibility with bone. However, wear of the coating over time may cause problems [4].
- **Laser Microstructuring:** Laser techniques allow the creation of precise microstructures on the surface. Osteoblast proliferation and differentiation are significantly increased with this technique [19].
- **Surface Chemical Properties:** The chemical composition of the surface affects biocompatibility and biological activity. For example, titanium and titanium alloys are widely used due to their low toxicity and specific biological interactions [20]. Hydrophilic surfaces facilitate the adhesion of blood proteins and osteogenic cells to the surface, supporting osseointegration. Implants with increased surface energy positively affect early stability [5]. Bioactive coatings support osteogenic cell proliferation.

The clinical success of dental implants depends on criteria such as early stability, bone loss rates, and long-term functional performance. Comparison of different surface designs with clinical data is important to determine which modifications are more effective [21]. Dental implant surface properties play a critical role in treatment success. Optimizing parameters such as surface roughness, chemical composition, and hydrophilicity accelerates osseointegration and increases long-term stability. Future research will continue to investigate the feasibility of new materials and techniques [22,23].

4.3. Clinical Importance of Implant Design and Surface Properties

- **Primary Stability:** The implant's thread structure and surface topography are key elements in ensuring initial post-surgical stability. Micro-abraded surfaces increase stability, especially in low-density bones [1].
- **Osseointegration:** Surface modifications at the micro- and nano-level can alter the connectivity of osteoblast fragments. Hydroxyapatite coatings accelerate bone growth [9].
- **Biomechanical Performance:** The geometric structure of the implant ensures that chewing forces are distributed evenly by the bone. Correct design and surface properties reduce the risk of premature implant failure [2].

4.4. New Technologies and Research

4.4.1. Nanotechnology

Nano-rough surfaces further increase cell proliferation and osseointegration. Bioactive nanoparticles are integrated into the implant surface, reducing the risk of infection [4].

4.4.2. Smart Implants

In recent years, advances in technology and biomedical engineering have brought intelligent implant systems to the forefront to increase the functionality of dental implants. Smart implants are equipped with biosensors and data collection systems to optimize treatment and increase long-term success rates (Figure 2) [24].

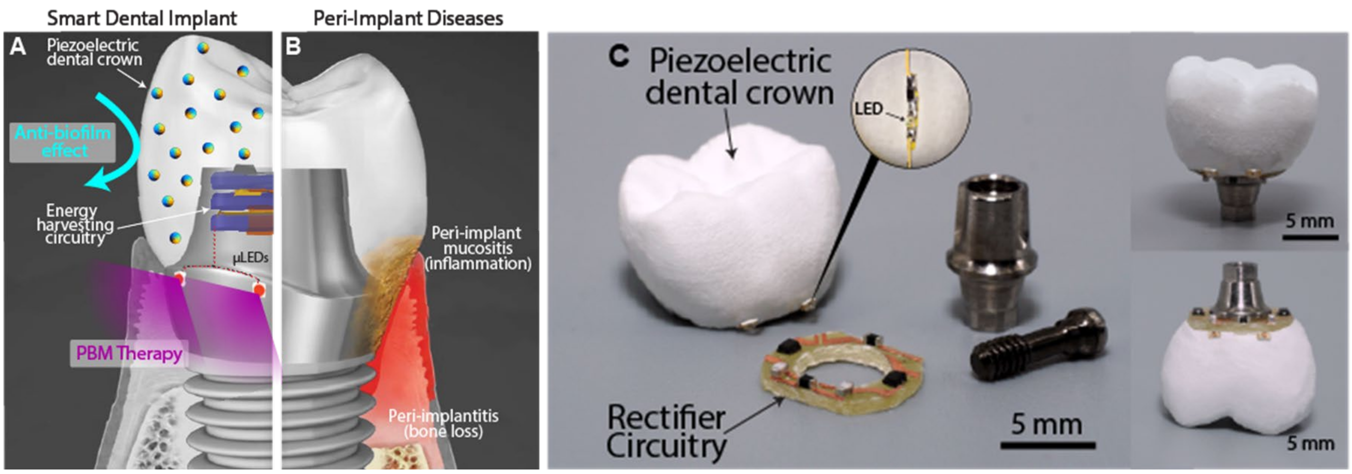

Figure 2: (A) Working of advanced smart dental implant system. (B) Inflammation around the implant. (C) First developed smart implant system [24].

a. Biosensors: Smart implants can continuously monitor the biological status of peri-implant tissues through biosensors. For example, they can provide real-time information on the presence of infection, environmental stresses, or the level of osseointegration. These biosensors detect pH levels, temperature changes, and load distribution [25]. Zhang et al. emphasized that these sensors are important for early diagnosis of infection [26]. Another study showed that biosensors can improve long-term implant success through the ability to detect microscopic changes in the osseointegration process [27]. Smart implants can continuously monitor the biological status of peri-implant tissues through biosensors and provide real-time information on infection, environmental stresses, or osseointegration level [28]. These biosensors can detect pH levels, temperature changes, and charge distribution [29]. Soares dos Santos and Bernardo highlighted the importance of these sensors for early diagnosis of infection [30]. Another study showed that biosensors could increase long-term implant success by detecting microscopic changes in the osseointegration process [31].

b. Data Collection and Transmission: These implants can transmit the data they collect to a device or a cloud-based platform via wireless communication systems. This allows physicians to monitor their patients remotely and makes it easier to intervene when necessary [26]. These systems play an important role in early infection diagnosis and preventing complications [32]. Cloud-based communication systems support clinical decision processes by accelerating data analysis. Wireless technologies increase efficiency in data transmission with low energy consumption and high accuracy rates. These findings show that the role of data collection and transmission in implant technologies is becoming increasingly critical [33].

c. Supporting the Healing Process: Some innovative implants can accelerate the healing process of peri-implant tissues, such as through regional stimulation or pharmacological agents. Furthermore, these systems can control micromovements to increase implant stability [34,35]. Pettersen et al. stated that electrical stimulation supports osseointegration by increasing osteoblast activity [34]. In addition, Apostu et al. discussed pharmacological approaches that may influence inflammation in peri-implant tissues [35]. These technologies hold promise for improving clinical outcomes.

d. Long-Term Success: Smart implants significantly increase the long-term success of implants by preventing early complications and optimizing osseointegration. This is a promising development, especially for patients in high-risk groups. Electrical stimulation supports osseointegration by increasing osteoblast activity [34]. Apostu et al. showed that pharmacological agents may affect peri-implant tissue responses and osseointegration [35]. Long-term case studies have reported that innovative implants may reduce the risk of infection and increase biomechanical stability. Such applications are important to increase clinical success, especially in patients at risk of complications.

5. Prosthetic Considerations

The design and placement of the prosthesis influence the long-term success of implants.

5.1. Types of Implant-Supported Restorations

Dental implant-supported prostheses can be divided into two main groups: fixed and removable options.

5.1.1. Fixed Prosthetics

Fixed dentures are permanently fixed on the implant and offer use similar to natural teeth.

- **Single Crowns:** These are used in cases where a single tooth is missing. They provide the closest solution to the natural tooth regarding esthetics and function [1].
- **Bridge Prosthetics:** In cases where more than one tooth is missing, prostheses are supported on two or more implants. They are especially preferred in cases where the edentulous area is long.
- **Full Arch Dentures:** In cases where all teeth in the jaw are missing, the prosthesis is fixed on four or six implants. This approach offers both esthetic and functional solutions [36].

5.1.2. Removable Dentures

Implants support removable dentures, but these prostheses can be removed by the patient.

5.1.2.1. According to Type of Support

- **Implant-Supported Complete Restorations:** These are used in completely edentulous jaws and stabilized with two or more implants.
- **Overdenture Prosthetics:** These are placed on natural tooth roots or implants. They are preferred especially when fixed prostheses cannot be made for economic reasons [9].

5.1.2.2. According to Type of Retention

- **Ball Attachment Prostheses:** These are small round connections holding the prosthesis on the implant. They are an economical and functional solution, especially for elderly patients [37].
- **Bar-Supported Dentures:** These are prostheses supported by a metal bar placed between two or more implants. They provide a more stable fit and minimize the movement of the prosthesis [38].
- **Magnetic Retaining Dentures:** Magnetic implant heads create a strong attraction between the prosthesis and the implant. However, the decrease in magnetic power over time is seen as a disadvantage [39].

Implant-supported dentures offer significant advantages in esthetics, functionality, and patient comfort when treating missing teeth. While fixed dentures provide a natural tooth feel, removable dentures are advantageous in terms of economy and hygiene. The type of denture to be preferred should be determined according to the patient's bone condition, financial possibilities, and personal expectations.

5.2. Material Selection and Properties

5.2.1. Metal-Ceramic Prosthetics

Metal-ceramic prosthetics are durable and long-lasting. Esthetic results are good thanks to the ceramic material, but they may offer a less natural appearance than complete zirconia prostheses.

5.2.2. Full Zirconia Restorations

Full zirconia restorations provide high durability and esthetics. They are resistant to chewing forces, especially in posterior regions [40].

5.2.3. All-Ceramic Restorations

All-ceramic restorations provide the highest esthetic results. They are preferred in the anterior region to provide a natural tooth appearance. However, the risk of fragility is higher in posterior areas [41].

5.2.4. PEEK

Polyetheretherketone is a light and biocompatible material. It is especially preferred in removable prostheses [42].

5.3. Prosthetic Design and Connection Types

5.3.1. Connection Types

- **Internal Conical Connections:** These reduce bone loss by minimizing micromovements and provide better esthetic results [1].
- **External Hex Connections:** This is a traditional method, but it carries a higher risk of micromovements.
- **Platform Switching:** The use of smaller-diameter abutments reduces marginal bone loss [2].

5.3.2. Design Factors

- **Occlusion Design:** Equal distribution of chewing forces should be ensured. Excessive stress loading may lead to implant failure [9].
- **Abutment Selection:** Zirconia abutments are preferred in esthetic areas, while titanium abutments are preferred in posterior regions.

5.4. Loading Protocols

One of the most critical factors affecting the success of dental implant treatments is the timing of implant loading. Loading protocols are classified as immediate, early, and delayed. The timing of prosthetic rehabilitation after implant placement is one of the factors that directly affects the osseointegration process and long-term success. Loading protocols refer to the application of prosthetic restoration in specific time periods following implant placement [43].

5.4.1. Immediate Loading

The prosthesis is loaded immediately after the implant is placed. Immediate loading is prosthesis loading within 48 hours following the surgical placement of the implant. This method is especially preferred in tooth deficiencies in the esthetic region and provides patients with rapid functional and esthetic gains [44]. However, bone quality and primary stability determine its success. It provides rapid fulfillment of esthetic and functional requirements, but the risk of failure due to inadequate primary stability is high.

5.4.2. Early Loading

The prosthesis is loaded in the initial phase of osseointegration. It is usually applied after 4–8 weeks. This protocol allows a certain amount of time for the osseointegration process while simultaneously providing patients with prosthetic rehabilitation in a shorter period [45]. Early loading is a safe option, especially in patients with adequate jaw bone density.

5.4.3. Delayed Loading

After complete osseointegration is achieved, usually after 3–6 months, the prosthesis is placed. The risk of complications is the lowest [46]. This protocol allows maximum time for the osseointegration process, so it has high long-term success rates and is especially preferred in patients with low bone density [17].

Comparison of Loading Protocols

Loading Protocol	Advantages	Disadvantages
Immediate Loading	Fast function, patient satisfaction	Requires primary stability, risk of bone loss
Early Loading	Shorter waiting time, acceptable success rate	Applicable in controlled cases
Delayed Loading	Optimal time for osseointegration, high success rate	Long waiting times may reduce patient satisfaction

Dental implant loading protocols should be determined according to the patient's bone quality, primary stability, and esthetic expectations. While immediate loading provides esthetic advantages, delayed loading is a reliable method for long-term success. The importance of patient-based loading protocols will increase with the development of individualized treatment approaches.

6. Patient Factors and Prosthetic Planning

- **Aesthetic Requirements:** Due to high esthetic expectations, complete ceramic prostheses are preferred in the anterior region.
- **Functional Requirements:** Zirconia prostheses are recommended in posterior regions where chewing forces are intense.
- **Economic Situation:** Material and design options are evaluated according to the patient's financial possibilities [47].
- **Psychosocial and Holistic Implications of Implant Therapy:** The impact of dental implant treatment extends beyond the restoration of oral function, encompassing psychological, socioeconomic, and overall physical health aspects. For many patients, implant therapy is not merely a functional intervention but also serves as a means of psychological rehabilitation, improving self-esteem, social confidence, and quality of life [55,56]. Recognizing and discussing these broader effects allows clinicians to adopt a more holistic approach, ensuring that treatment planning addresses both the functional and psychosocial needs of patients. Incorporating these dimensions into the clinical decision-making process may enhance patient satisfaction and overall treatment outcomes [57].

7. Post-Operative Care and Maintenance

Regular follow-ups and maintenance care are crucial to prevent peri-implant diseases.

7.1. Peri-Implant Mucositis and Peri-Implantitis

- Early detection and treatment of mucositis prevent progression to peri-implantitis.
- Non-surgical and surgical interventions may be required, including debridement and regenerative procedures.

7.2. Patient Compliance

Patients must adhere to prescribed hygiene protocols and follow-up schedules to maintain implant health [48].

8. Technological Advancements

Recent innovations are enhancing success rates in dental implantology.

- **3D Printing:** This technology enables custom implant designs and accurate surgical guides [49].
- **Digital Workflow:** Digital workflow facilitates precise implant placement through computer-aided design and computer-aided manufacturing [50].
- **Biological Enhancements:** Growth factors such as bone morphogenetic proteins and platelet-rich fibrin accelerate healing [51].

SUMMARY / SONUÇ

Dental implant therapy represents a multidimensional intervention that extends beyond the mere restoration of oral function, impacting patients' psychological, socioeconomic, and overall health. The literature indicates that advanced age alone does not significantly reduce implant success; however, factors such as systemic health status, bone quality/volume, and patient compliance play a decisive role in treatment outcomes.

Considering individual patient characteristics during treatment planning is critical. Factors such as age, sex, socioeconomic status, psychological condition, and lifestyle can influence both short- and long-term success. In particular, bone condition and osseointegration potential have a direct impact on implant selection and placement strategies. Furthermore, patient expectations, aesthetic concerns, and the effects on social life emerge as significant psychosocial determinants that shape the overall success of treatment.

Within this framework, personalized treatment planning should address both functional and psychosocial needs. Adopting such a holistic approach in clinical decision-making enhances patient satisfaction and improves the predictability of treatment outcomes. In summary, implant therapy should be regarded not merely as a technical procedure but as a multidimensional healthcare intervention optimized according to the individual patient profile.

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