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OCCLUSION IN FIXED FULL-ARCH IMPLANT PROSTHESES

SABİT TAM ARK İMPLANT PROTEZLERDE OKLÜZYON

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Abstract

Nowadays, full-arch implant prostheses have become a popular treatment method for the rehabilitation of edentulous patients. Studies have found that prosthetic complications are higher than biological complications. Prosthetic complications may include acrylic tooth fracture, veneer porcelain fracture, screw loosening or breakage, premature wear of acrylic teeth, and framework fracture. Such complications may result in multiple repair costs, increased laboratory expenses, and dissatisfied patients. Occlusion is a risk factor for prosthetic complications of full-arch implant-supported prostheses. However, little is known about the occlusal planes of full-arch implant-supported prostheses. Most existing studies only briefly mention the occlusal plane used in prosthesis design. The selection criteria for a particular occlusal scheme are usually based on empirical evidence or the clinician's occlusal philosophy.

Additionally, occlusal considerations for various materials or opposing teeth are often unclear in studies. This review describes the current principles of occlusion and their use in implant-supported fixed full denture restorations. A simplified guide will be helpful to clinicians when planning the occlusion of full-arch fixed implant-supported prostheses made of various materials, whether against artificial or natural teeth.

Keywords: *Implant Supported Dentures, Dental Implants, Dental Occlusion, Occlusal Plane.*

Özet

Günümüzde, tam ark implant protezleri dişsiz hastaların rehabilitasyonu için popüler bir tedavi yöntemi haline gelmiştir. Çalışmalar, protez komplikasyonlarının biyolojik komplikasyonlardan daha yüksek olduğunu göstermektedir. Protez komplikasyonları arasında akrilik diş kırığı, veneer porselen kırığı, vida gevşemesi/kırılması, akrilik dişlerin erken aşınması ve iskelet kırığı yer alabilir. Bu tür komplikasyonlar, çoklu onarım maliyetlerine, laboratuvar maliyetlerine ve memnuniyetsiz hastalara yol açabilir. Oklüzyon, tam ark implant destekli protezlerin protez komplikasyonları için bir risk faktörüdür. Ancak, tam ark implant destekli protezlerin oklüzal düzlemleri hakkında çok az şey bilinmektedir. Mevcut çalışmaların çoğu, protez tasarımında kullanılan oklüzal düzlemi yalnızca kısaca belirtmektedir. Belirli bir oklüzal şema için seçim kriterleri genellikle ampirik kanıtlara veya klinisyenin kendi oklüzal felsefesine dayanmaktadır.

Ek olarak, farklı malzeme türleri veya karşıt dişler için oklüzal hususlar çalışmalarda genellikle belirsiz kalmaktadır. Bu derleme, oklüzyonun güncel prensiplerini ve implant destekli sabit tam protez restorasyonlarında kullanımını açıklamaktadır. Basitleştirilmiş bir kılavuz, çeşitli

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malzemelerden yapılmış tam ark sabit implant destekli protezlerin yapay veya doğal dişlere karşı oklüzyonunu planlarken klinisyene yardımcı olacaktır.

Anahtar Kelimeler: *İmplant Destekli Protezler, Dental İmplantlar, Dental Oklüzyon, Oklüzal Plan.*

OVERVIEW / GENEL BAKIŞ

Thanks to the high success rates of modern implantology, completely edentulous patients can improve their quality of life. The literature has demonstrated that fixed full-arch implant restorations offer several advantages over removable implant-supported prostheses, including enhanced chewing strength and efficiency, higher satisfaction rates, reduced maintenance requirements, improve done integrity, and superior prosthetic success rates (1).

Fixed full-arch implant restorations usually replace missing teeth and use a pink-colored material such as acrylic, porcelain, or zirconium to compensate for soft tissue. The fixed full-arch implant prosthesis was created as a "hybrid" prosthesis with a metal substructure containing prosthetic teeth and acrylic (Table 1) (2). However, this type of Prosthesis is subject to high maintenance issues and a high incidence of complications, such as excessive wear or separation of the prosthetic teeth (3).

Advanced technological developments are used to eliminate the complications of porcelain-metal Prosthesis. Many complications are seen in this type of restoration, such as a high incidence of porcelain fracture and difficulty in ensuring passive seating of the Prosthesis. Recently, monolithic zirconium has been successfully used to produce this type of Prosthesis. This Prosthesis has superior strength, low fracture probability, and high wear properties (4). Complete arch implant prostheses made of monolithic zirconia have superior aesthetics and solve the disadvantages of previous prostheses (5).

Table 1: Misch's classification of implant-supported prostheses (2).	
Type Discrimination	
FP-1	A fixed prosthesis only restores the crown, making it look like a natural tooth.
FP-2	The Fixed Prosthesis restores the crown and the root; the contours of the crown are normal in the occlusal half, but the gingival is extended or over-contoured in half.
FP-3	Fixed Prosthesis restores the missing crown, gum color, and part of the toothless area.
RP-4	Removable Prosthesis is only implant-supported.
RP-5	Removable is supported by implants and soft tissues

Full Edentulous Arch Rehabilitation

The correct occlusal plane is crucial to optimizing the longevity of a fully implant-supported full-arch prosthesis. However, there is considerable debate regarding occlusal recommendations for

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implant-supported prostheses. Most occlusal concepts used in implant dentistry have evolved from those employed in complete dentures and fixed tooth-supported prostheses. There are currently no controlled studies on the ideal occlusion for fixed implant-supported prostheses. Therefore, there is no consensus on the ideal occlusal scheme for patients. There are many variables involved in rehabilitating an edentulous arch with dental implants. Treatment planning is crucial. The number, location, surface area of implants, opposing dentition, parafunctional habits, and cantilevers must be considered. The profession needs a decision tree to determine the type of occlusion to be used in fully implant-supported prostheses. Three ideal occlusal schemes are recognized in the literature for full-arch restorations based on mandibular functional movements: bilateral balanced, group function, and mutually maintained occlusion.

I. Bilateral Balanced Occlusion

Bilateral balanced occlusion is simultaneous anterior and posterior occlusal contact in centric and eccentric positions. This occlusal scheme is primarily used in complete dentures, where the contact on the non-working side prevents the denture from tipping. Balanced occlusion in natural teeth is rarely seen without extensive and advanced wear (Fig. 1). This occlusal plane is used only in cases where the arch is restored with a conventional prosthesis or with a soft tissue-supported maxillary prosthesis for full arch implant restorations. Lingualized occlusion is a bilateral balanced occlusion in which the maxillary lingual cusps come into contact with the occlusal surfaces of the mandibular teeth during central and eccentric movements of the mandible. In this type of occlusion, anatomy, esthetic maxillary teeth, and mechanically free mandibular non-anatomical teeth are used (6).

Figure 1: Bilateral balanced occlusion on natural teeth.

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Correct occlusion arrangement in implant-supported prostheses minimizes the pressure on the jaw joint and surrounding tissues. Bilateral balanced occlusion provides equal force distribution on both jaw sides, ensuring symmetrical teeth contact during chewing (7). This occlusion type enhances the effectiveness of implant-supported prostheses and protects joint health. Establishing this balance in the design of prostheses ensures a homogeneous distribution of forces between teeth and implants during chewing (8,9). It also prevents problems such as peri-implantitis by ensuring that the bone tissue around the implant remains healthy (10). Several factors must be considered in implant-supported prostheses to ensure bilateral balance. First, the natural movements of the jaw and teeth must be regarded as part of implant prosthetic treatment. During the placement of the prostheses, correct occlusion arrangements must be made to ensure an equal distribution of force in both jaws. During the fixation of the prostheses, especially in total prostheses, maintaining bilateral balance reduces possible stresses on the jaw joint (11). There are various techniques to provide bilateral balanced occlusion. These techniques include optimizing the prosthesis design, adjusting torques, and simulating jaw movements. In addition, performing occlusion tests after placing the Prosthesis and making necessary adjustments is an essential factor that increase the success of the treatment (12).

Bilateral balanced occlusion is an occlusion arrangement that provides simultaneous contact in both jaw arches and eccentric movements in the centric occlusion position. In this type of occlusion, balanced contact occurs between opposing teeth, especially during lateral movements, and chewing forces are distributed throughout the arch. Traditionally used in complete dentures, these principles are also applied to increase stability in implant-supported complete dentures (8). In implant-supported prostheses, bilateral balanced occlusion increases stability by minimizing the movement of the Prosthesis during chewing. Balanced contact allows occlusal loads to be distributed equally, reducing biomechanical stresses around the implant (13). Proper occlusion reduces the loads on the temporomandibular joint (TMJ) and prevents excessive strain on the jaw joint. Bilateral balanced occlusion can help prevent TMJ disorders by optimizing joint function, especially in patients undergoing full-ch rehabilitation (14). Balanced occlusal forces reduce the risk of fracture and wear of implant-supported prostheses. Especially in complete arch prostheses, bilateral balanced occlusion application ensures the longevity of the Prosthesis (15). A balanced contact distribution allows the chewing function to be performed more effectively. Bilateral balanced occlusion increases the food grinding capacity by enabling patients to use their chewing force more efficiently (8).

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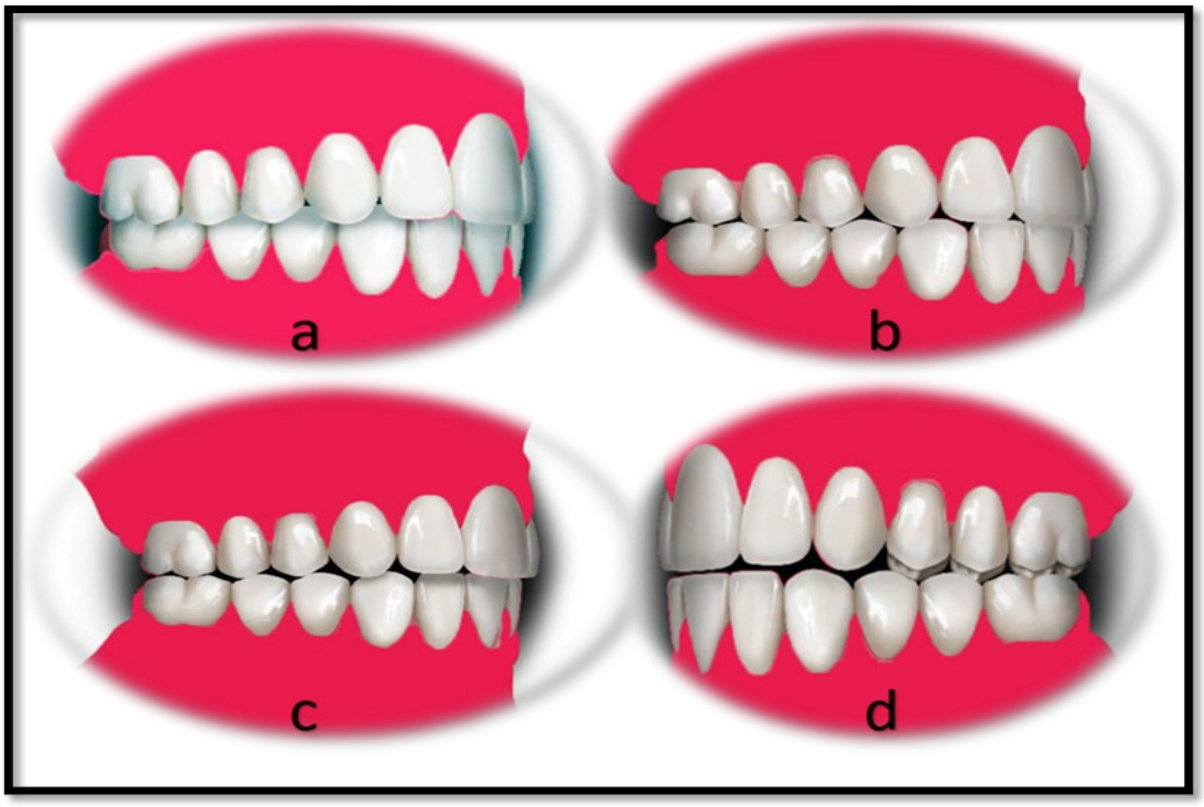

Figure 2: (a) In bilateral balanced occlusion, there should be simultaneous anterior and posterior contact in centric relation. (b) During protrusive movement, there are simultaneous bilateral contacts. There are posterior contacts on the right lateral working side (c) and balancing sides (d).

II. Group Function Occlusion

The group function is also called unilateral balanced occlusion and involves simultaneous contact between multiple teeth on the working side during eccentric movement of the mandible. The group function is performed with lateral contacts on the working arch side and without lateral contacts on the non-working side. Group function occlusion is a type of occlusion in which the canine, premolar, and sometimes molar teeth come into contact with each other during laterotrusion movement (Fig. 3). This concept aims to reduce single-oth loading by spreading the occlusal loads over a wider area (16,17). This occlusion is primarily used in deformed canines to transmit lateral forces to the posterior teeth, rather than the canines. Contacts on the deformed side are traumatic to the teeth, causing neuromuscular disorders, accelerated periodontal deterioration, and excessive wear (18).

Group working occlusion is an occlusion system provided by the mutual contact of more than one tooth in the upper and lower jaw during deterioration. This type of occlusion works by connecting the forces exerted on the jaw joints, ensuring that the teeth in both jaw regions carry equal loads. In implant-supported prostheses, this occlusion facilitates functionally symmetrical jaw movements, similar to those achieved in treatments performed with natural teeth (12). The provision of group function occlusion in implant-supported prostheses provides several clinical benefits. Firstly, this type

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of occlusion helps distribute forces homogeneously between the teeth or implants during chewing, therebynsuring the longevity of the prostheses (12). Additionally, group functional occlusion can help prevent temporomandibular joint (TMJ) disorders by preventing excessive pressure on the jaw joint. (11). Group function occlusion can also help preserve the periodontal tissues around the teeth and implants. This balance supports the health of the peri-implant tissues and prevents bone loss around the implant (10,19).

There are several methods to ensure group functional occlusion in implant-supported prostheses. In the prosthesis design, the teeth and implants in both jaws must be aligned correctly. Jaw movements, especially lateral and protrusive movements, must be carefully analyzed to maintain group functional occlusion (8). In the design of prostheses on implants, ensuring group functional occlusion distributes the loads on the jaw joint symmetrically, protects joint health, and increases the stability of the Prosthesis (14). In addition, it is imperative to ensure group functional occlusion in treatments for total prostheses. In such prostheses, an equal force distribution on both jaw sides increases the Prosthesis's durability and the patient's comfort (7).

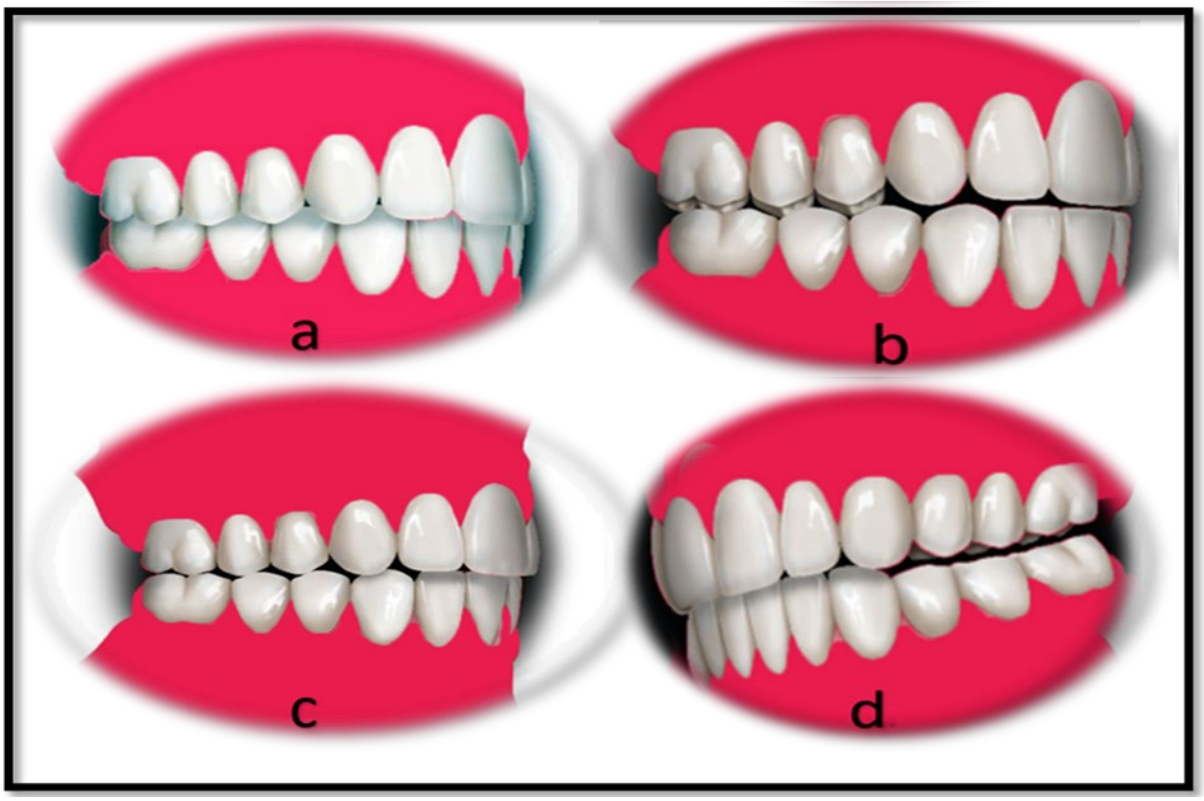

Figure 3: Group function occlusion; (a): centric position ;(b): protrusive position (c): working side; (d): non-working side.

III. Mutually Protected Occlusion

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Mutually protected occlusion, also called canine protected or organic occlusion. An occlusal arrangement in which the anterior teeth protect the posterior teeth by keeping them out of contact with the opposing teeth during eccentric movements. The canines protect all other teeth during lateral movements, while the posterior teeth protect the anterior teeth in centric relationships. This occlusal arrangement is based on the concept that the canines are a critical occlusion element and that heavy lateral pressure on the posterior teeth is prevented (Fig. 4) (20). This occlusal scheme is used when a full-arch implant restoration opposes an arch with natural teeth or is restored with a fixed implant prosthesis or an RP-4 implant-supported maxillary prosthesis. In addition, in a full-arch fixed implant prosthesis, the following must be integrated into the occlusal scheme: bilateral stability in centric occlusion; freedom in centric occlusion; narrow occlusal table; minimum cusp height; evenly distributed occlusal forces; no interference between the most posterior position and the centric position; and frictionless and even lateral free movements without interference on the working or non-working side (21).

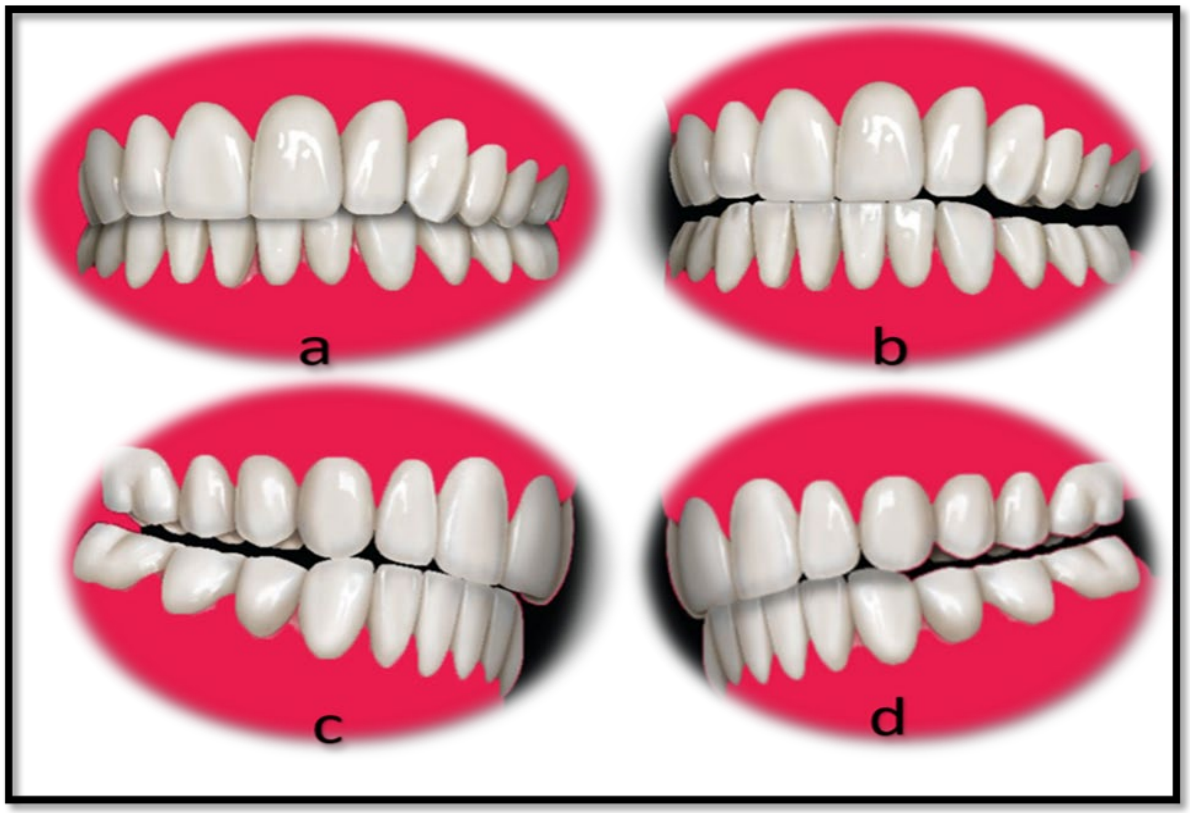

Figure 4: Mutual protection occlusion involves designing the anterior, canines, and posterior teeth to optimize their specific functions:

- Maximum Intercuspation (MI): Provides complete contact of the posterior teeth (a);
- Protrusive Movement: Anterior teeth guide to eliminate posterior contact (b);
- Lateral Movements: Chewing stability is achieved by choosing canine guidance or group function (c, d).

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Complete arch implant prostheses have the correct occlusal scheme to minimize implant losses and increase prosthesis life. A poorly designed occlusal scheme can cause biological and mechanical changes, resulting in biomechanical stress and strain on the bone. These biomechanical overloads may cause early or late implant loss, early crestal bone loss, screw loosening or fracture, prosthesis decementation, or prosthesis fracture (22).

Implant-Protected Occlusion Principles

To minimize occlusion-related problems, Dr. Misch developed the concept of implant-protected occlusion (IPO), which helps reduce excessive force loading on the implant prosthesis and crestal bone. In addition to the occlusal schema recommendations provided above, adhering to the following IOP principles can help reduce biomechanical stress on the implant interface and maximize the success of a full-arch prosthesis.

1. Ideal Implant Position

Multiple key implant positions are essential to reduce force in full-arch prostheses. If one of the terminal supports of the restoration is a canine, a second implant is required. In the case of 3 adjacent tooth losses in the posterior, the 1st molar tooth is the key-lock implant position. If one implant is used in the 1st molar deficiency, the diameter should be at least 5 mm. The implant diameter should be considered for two premolar teeth if it is narrow. In addition, an implant positioned in the incisor area should be used to minimize the effect of anterior tipping (2).

2. Increased Implant Surface Area

Ideally, the number of implants and implant body surface area should be increased, especially when the opposing occlusion is natural teeth or parafunctional habits are present. Decreased implant surface area increases prosthesis stress and strain and possibly biomechanical overload.

3. Minimized Distal Extensions (Cantilevers)

Cantilevers are frequently used in complete arch implant prostheses to accommodate the first molar in the maxilla or mandible due to maxillary sinus pneumatization and loss of mandibular posterior bone. Cantilevers are force enhancers, resulting in tensile forces that increase stress on the implant and Prosthesis. Due to the destructive effects of cantilevers, peri-implant bone loss and prosthesis failure are frequently observed (Fig. 3)(23,24). Cantilevers magnify the forces on implants, abutment screws, and elements that hold the Prosthesis. Cantilevers can be used directly with additional force on the length of the prosthesis support (25). The implant system is exposed to a force of 25 lb at the beginning of the long-term spread of the implant. The same force on the abutment on a 10 mm cantilever grows by 250 lb*mm—Cantilever restorations containing more than one implant work as a first-class lifting system. A fulcrum burst occurs on the abutment adjacent to the cantilever.

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The force on the abutment close to the cantilever is the sum of the forces on the two arms of the lifter. Cantilever construction should not be considered in the ideal treatment plan. Some varieties can be done in the form of cantilever maintenance and extraction. In advanced resorption cases where implants at the terminal margin cannot be placed, parafunction, crown effacement, fracture dynamics, implant placement, and force capabilities such as opposing arch should be examined and evaluated (2).

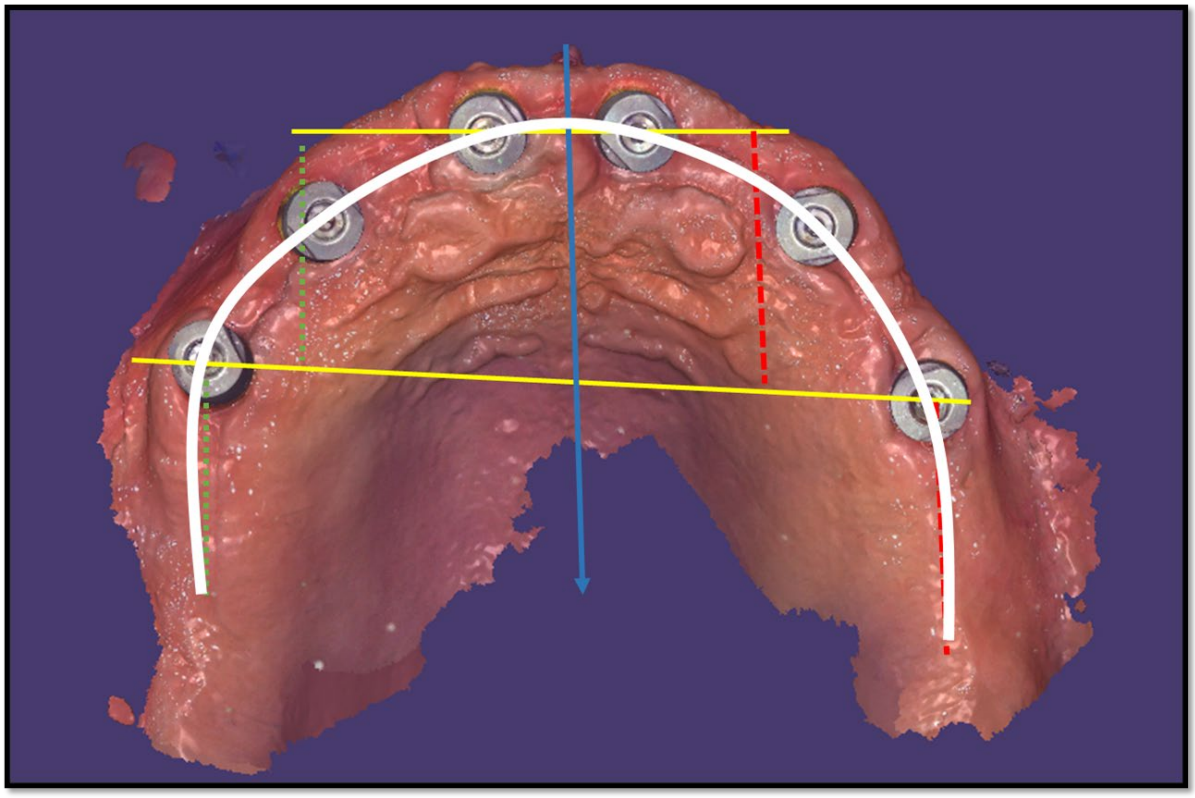

Figure 5: The cantilever can be as long as the distance between the lines passing through the front and backmost implants.

4. Shallow Anterior Guidance

With a fixed full-arch implant prosthesis, anterior guidance should remain shallow. The steeper the incisor guidance, the greater the resultant force on the anterior segment. For every 10-degree increase in incisor guidance, there is a 30% increase in force applied to the anterior segment. Additionally, increased anterior guidance results in higher posterior contact, leading to more significant muscle activity (26).

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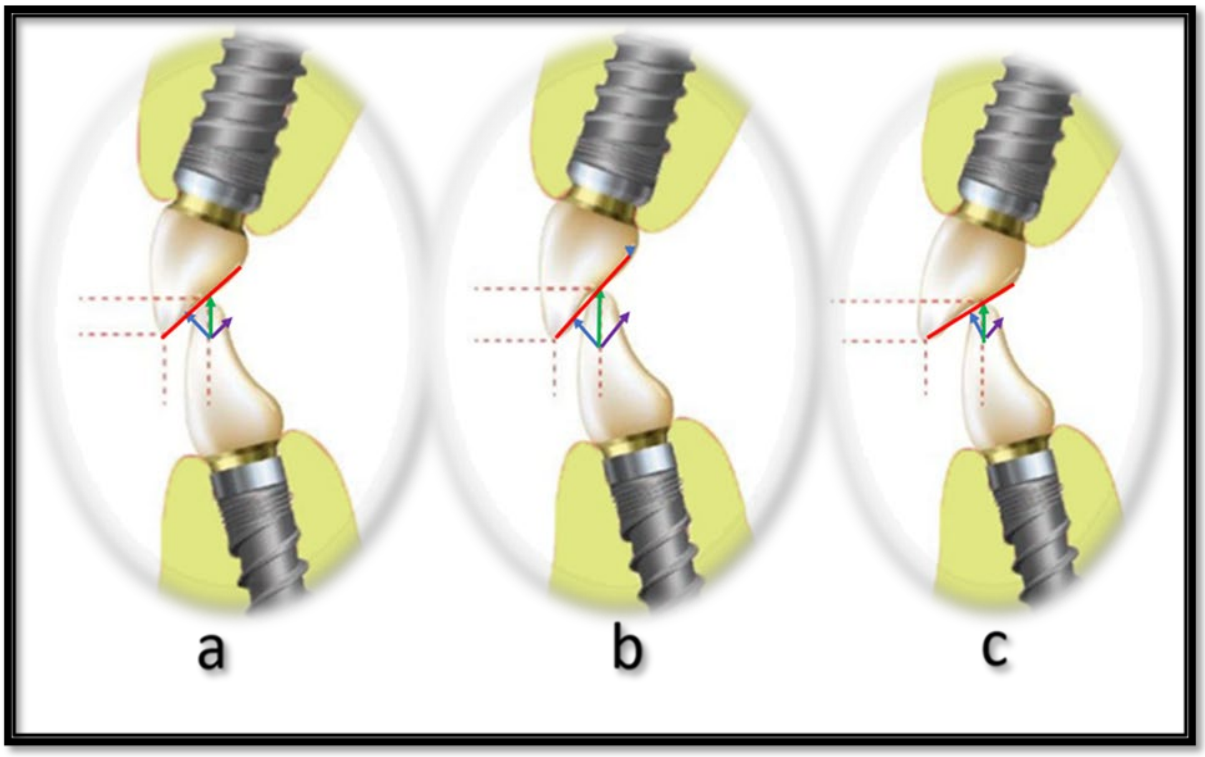

Figure 3: Overjet and overbite relationship between anterior teeth. The overbite decreases to reduce anterior orientation (b to a), or the overjet increases (b to c).

5. Occlusal Protection

In an implant-supported prosthesis, there is no sensory system (i.e., proprioception) that protects against large biting forces, unlike natural teeth. Patients are less aware of early contacts that may cause biomechanical overload. A patient with a full-arch implant will benefit from an occlusal guard, especially if there are parafunctional habits.

Clinical Protocol for Occlusion Adjustment

Clinical applications of occlusion in implant-supported prostheses are carried out by following certain steps:

Patient Assessment and Diagnosis

- Occlusion analysis is performed.
- The temporomandibular joint (TMJ) and jaw muscles are evaluated.
- Existing tooth contacts are determined (27).

Digital and Traditional Model Analysis

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- Imaging techniques are used (e.g., digital scans and articulators).
- An occlusion design tailored to the patient is created (28).

Occlusion Adjustment and Restorative Planning

- Correct contact points are determined.
- Necessary occlusal adjustments are made to distribute the loads evenly.
- Optimal contact is achieved with composite or ceramic restorations (29).

Stabilization of Occlusion

- Supported by occlusion splints or night guards.
- Healing treatments and patient-specific protective approaches are applied (30).

Following and Evaluation

- The patient is checked at regular intervals.
- Changes in tooth contacts are monitored, and readjustments are made if necessary.

Planning occlusion under clinical protocols is critical to long-term success (31).

An occlusal guide was developed for five possible scenarios of opposing jaws and different prosthesis materials for full-arch implant-supported prostheses (Table 2) (32). The guide aims to minimize prosthetic complications and maximize patient comfort and function.

Table 2: Summary of different scenarios that may present as a choice during full arch/full mouth rehabilitation with implant-supported prostheses (32).

Scenarios	Centric Contact	Excursive movements	Zr Framework Design
Metal-Acrylic Vs Metal-Acrylic	Simultaneous bilateral contact Shim stock clearance (10 µm) on cantilevers and anterior -Freedom in centric(1.0–1.5 mm)	Laterotrusion: Group function Protrusion: Shallow anterior guidance No contact on the cantilever	N/A
Metal-Acrylic Vs Natural Dentition	Simultaneous bilateral contact Shim stock clearance (10 µm) on cantilevers and anterior -Freedom in Centric(1.0–1.5 mm)	Laterotrusion: Canine guidance (sound canine) Group function (compromised canine) Protrusion: Shallow anterior guidance No contact on the cantilever	N/A
All Ceramic/Zirconia Vs All Ceramic/Zirconia	Simultaneous bilateral contact Equal intensity contact on posteriors and interiors Shim stock clearance (10 µm) on cantilevers -Freedom in centric (1.0–1.5 mm)	Laterotrusion: Group function -Protrusion: Shallow anterior guidance -No contact on the cantilever	Full contour monolithic - Veneering porcelain limited to facial/buccal
All Ceramic/Zirconia Vs Metal Acrylic	Simultaneous bilateral contact Shim stock clearance (10 µm) on cantilevers Freedom in centric(1.0–1.5mm	Laterotrusion: Group function Protrusion: Shallow anterior guidance -No contact on the cantilever	Full contour monolithic - Veneering porcelain limited to facial/buccal

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All Ceramic/Zirconia Vs Natural Dentition	Simultaneous bilateral contact -Shim stock clearance (10 µm) on cantilevers and anterior -Freedom in centric(1.0–1.5 mm)	Laterotrusion: Canine guidance (sound canine) Group function (compromised canine) -Protrusion: Shallow anterior guidance -No contact on the cantilever	Full contour monolithic - Veneering porcelain limited to facial/buccal

SUMMARY / SONUÇ

Occlusion plays a vital role in the survival of a full-arch implant-supported prosthesis (Table 3). It may be modified accordingly in the presence of adverse individual clinical determinants, such as occlusal planes, implant position, number of implants, their distribution, skeletal relationship, occlusal vertical dimension, and esthetic occlusal plane orientations, depending on the amount of cantilever and lip support. The most common complications of full-arch implant prostheses are crestal bone loss, screw loosening or fracture, and decementation. Complications that may lead to Prosthesis or implant failure are related to biomechanical overload. It is crucial to integrate the concept of implant-protected occlusion with reducing force factors. Therefore, it is essential to control and maintain occlusion to reduce mechanical and biological complications, thereby prolonging the life of the Prosthesis.

Table 3: Occlusion in implant-supported restorations

	Restoration Type	**Opposite Arc Status**	**Occlusion Type**
Implant-Supported Removable	Implant Supported Only (RP-4)		Canine Protective Occlusion or Group Function
	Implant and Soft Tissue Supported (RP-5)		Bilateral Balanced Occlusion
Implant-Supported Fixed	Edentulous Maxilla	Natural Dentition	Canine Protective Occlusion or Group Function
	Edentulous Mandible	Natural Dentition	Group Function
	Edentulous Maxilla or Mandible	Complete Denture	Bilateral Balanced Occlusion
	Edentulous Maxilla	Fixed Prosthesis	Canine Protective Occlusion or Group Function
	Edentulous Mandible	Fixed Prosthesis	Group Function
	Anterior Implant-Supported Partial Prostheses		Canine Protective Occlusion or Group Function
	Posterior Region Implant-Supported Partial Prostheses	Canine Tooth Presence	Canine Protective Occlusion
		Canine Tooth Missing	Group Function
	Single Tooth Missing (Missing Canine)		Group Function
	Single Tooth Missing		Patient's Own Occlusion or Canine Protective Occlusion

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