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"Everything About Occlusion in Implants - A Review Article"

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Abstract
Advancements in medical science have increased focus on dental health, with dental implants emerging as a leading solution for tooth replacement. The success of these implants is heavily influenced by mechanical conditions, particularly occlusal loading. Optimal implant positioning and occlusal schemes are critical yet challenging, often based on empirical rather than evidence-based decisions. Implants differ from natural teeth in periodontal support, biomechanical design, sensory perception, and response to occlusal forces, impacting their durability and stress distribution. Successful implant occlusion requires TMJ functionality, harmony of anterior and posterior teeth, and effective masticatory muscle coordination. "Implant-protected occlusion" (IPO) emphasizes harmonious occlusal relationships to prevent complications. Key considerations include eliminating premature contacts, ensuring mutually protected articulation, and designing prostheses to favor the weaker arch. Understanding stress dynamics between natural teeth and implants is crucial for minimizing complications. Careful occlusal planning and adjustments are essential for the longevity and functionality of implant-supported prostheses.

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I. Introduction

Advancements in medical science have extended human life expectancy, driving a heightened emphasis on dental health and aesthetics. With a desire for fuller, healthier lives, an increasing number of patients seek dental solutions that offer functional and aesthetic benefits akin to natural teeth. Dental implants have emerged as the premier choice for tooth replacement, aiming to restore function, form, and aesthetics while ensuring longevity.[1] However, the success and durability of endosteal dental implants hinge significantly on the mechanical conditions they endure. Common complications stem from biomechanical factors such as porcelain fracture, prosthesis retention issues, and implant component failure. Moreover, occlusal loading imposes significant stresses on implants and surrounding tissues post-rehabilitation, necessitating careful planning to support functional demands.[2] Clinicians face challenges in determining optimal implant distribution, angulation, and position, often relying on empirical decisions rather than evidence-based approaches. The choice of occlusion scheme for implant-supported prostheses is complex and contentious, with various paradigms influencing treatment decisions.[3] Occlusion plays a pivotal role in prosthodontic care, impacting the success of intraoral prostheses and restorations. It encompasses the dynamic relationship between teeth, neuromuscular system, and TMJ, crucial for achieving functional and aesthetic success, particularly in implant-supported prostheses.[4] The occlusal scheme becomes especially critical during parafunctional activities and when the implant foundation is suboptimal, as it affects load distribution and biomechanical stress. While many implant occlusal concepts derive from natural dentition principles, modifications are necessary due to the increased biomechanical risks associated with implants compared to natural teeth.[5,6]

II. Definition

Clear and consistent terminology is essential for effective communication. It should be standard, unambiguous, and descriptive. With precise terminology, we can infuse philosophical insights into every aspect of our discussions.[7]

- **Centric relation:** The most retruded relation of the mandible to the maxillae when the condyles are in the most posterior unstrained position in the glenoid fossae from which lateral movement can be made at any given degree of jaw separation
- **Centric occlusion:** The occlusion of opposing teeth when the mandible is in centric relation. This may or may not coincide with the maximal intercuspal position.
- **Condylar guidance**: Mandibular guidance generated by the condyle and articular disc traversing the contour of the glenoid fossa.
- **Deflective occlusal contact:** A contact that displaces a tooth, and diverts the mandible from its intended movement.
- **Disclusion**: Separation of opposing teeth during eccentric movements of the mandible
- **Eccentric relation**: any eccentric relationship position of the mandible relative to the maxilla, whether conditioned or learned by habit, which will bring the teeth into contact

III. Primary Requirement For Successful Occlusion

The dental implant serves as a supportive structure for various dental prostheses, providing stability and retention. The success of these implants relies heavily on the mechanical environment, particularly the occlusion, which is crucial for their longevity. The concept of "implant-protected occlusion" refers to an occlusal scheme tailored for endosteal implant prostheses, emphasizing harmony between the temporomandibular joint (TMJ), teeth, and muscles.[8-10]

❖ **For successful occlusal therapy, several primary requirements must be met:**

1. TMJ functionality and comfort are paramount, ensuring they can handle loading forces without discomfort.
2. Anterior teeth must harmonize with the functional movements of the jaw and maintain proper relationships with surrounding structures.
3. Posterior teeth should not interfere with TMJ comfort or anterior guidance.
4. Harmony between TMJ, anterior guidance, and posterior teeth is necessary to coordinate masticatory muscles effectively.[11]

The components of occlusion include the temporomandibular joint (TMJ), muscles, and teeth. The TMJ is a complex joint between the mandible and the skull, with movements involving rotation and gliding. Muscles controlling mandibular movement include elevators (closing muscles), guiding muscles, and depressors (opening muscles). These muscles act via contraction and determine the direction and force of mandibular movement. Teeth play a crucial role in occlusion, with sensory impulses from proprioceptive receptors influencing muscle activity. Natural teeth continually adjust to wear, but gross irregularities may require intervention. Imbalances in occlusion can lead to mandibular displacement, but properly constructed prostheses can restore normal function. However, edentulous patients may struggle with mandibular positioning due to the loss of proprioceptive mechanisms provided by natural teeth.[11-12]

IV. Natural Tooth Versus Implant Biomechanics

In comparing natural teeth to dental implants in terms of biomechanics and load response, several key distinctions emerge:[13]

1. Periodontal Support:- Natural teeth are supported by the periodontal ligament, acting as a shock absorber and distributing forces around the tooth. Implants, on the other hand, rely on direct bone-implant connection, leading to higher impact forces primarily directed to the crest of the bone.

2. Biomechanical Design: - Natural teeth have a cross-section tailored to handle stress, with an elastic modulus similar to bone. Implants typically feature a round cross-section and are designed for surgery, with a significantly higher elastic modulus compared to cortical bone.

3. Sensory Perception:-Natural teeth possess sensory nerves, providing feedback on occlusal trauma and bite force. Implants lack sensory nerves, resulting in less awareness of occlusal forces and higher functional bite force.

4. Occlusal Material and Surrounding Bone: - Natural teeth have enamel as the occlusal material and are surrounded by cortical bone, resistant to change. Implants often use porcelain or metal crowns, and the surrounding bone is trabecular, more prone to changes under load.

5. Impact on Load: - Natural teeth experience decreased impact force due to the periodontal ligament, while implants face increased force impact, mainly directed to the crest.

6. Mobility and Diameter:- Natural teeth may exhibit variable mobility, especially in anterior teeth, whereas implants are rigid with no mobility. Additionally, natural teeth typically have a larger diameter compared to implants.

7. Hyperaemia and Orthodontic Movement: - Natural teeth may induce hyperemia and allow orthodontic movement, while implants do not exhibit these characteristics.

8. Occlusal Overload and Stress Distribution: - Occlusal overload on natural teeth can lead to enamel wear, pain, and mobility, whereas implants may experience screw loosening, bone loss, or fracture under excessive stress. The stress distribution pattern differs between natural teeth and implants, with the periodontal ligament acting as a shock breaker for natural teeth and implants capturing stress at the crest of the bone.

Overall, while both natural teeth and implants serve as functional components in the oral cavity, their biomechanical responses to load differ significantly, influencing their durability and response to occlusal forces.

V. Goals and Aims of Implant Occlusion

The goals and aims of implant occlusion aim to ensure optimal function and longevity of implant-supported prostheses while minimizing harm and risks.

- **Occlusal Goals**:[14]

1. Achieve bilateral simultaneous contact.
2. Avoid prematurities in the retruded contact position (RCP).
3. Enable smooth, even lateral excursive movements with no interferences.
4. Ensure equal distribution of occlusal forces.

- **Aims for Implant-Supported Prosthesis**:[15]

1. Maximize occlusal function.
2. Minimize harm to opposing and adjacent teeth.
3. Reduce wear on occlusal surfaces.
4. Minimize the risk of implant superstructure fracture.
5. Reduce the risk of implant body and connecting component fracture.
6. Protect the implant-host interface.

- **To achieve these aims, several principles must be considered**:[16]

1. Location: Anatomical constraints may limit ideal implant placement, affecting load distribution and torque forces.
2. Rigidity Under Load: Implants are less flexible than natural teeth and move linearly under load, impacting occlusal contact distribution.
3. Immovability: Implants cannot be orthodontically moved or intruded for occlusal modification.
4. Proprioception: Implants lack the sensitivity of natural teeth due to the absence of a periodontal membrane.
5. Biomechanical Overload: Implant-supported prostheses can generate higher forces, potentially causing damage to opposing prostheses and underlying tissues.
6. Mechanical Linkages: Implants rely on mechanical components prone to failure under overload. Design considerations, including component size, construction quality, cantilevering, and occlusal scheme, impact the risk of failure and tissue damage.

In summary, harmonizing occlusal schemes with the biological environment is crucial for implant-supported prostheses to prevent potential complications arising from excessive forces or mechanical issues.

VI. Concepts of Occlusion

- **Ideal Occlusion:** Ideal occlusion refers to a harmonious alignment of teeth and jaw movements that promote efficient chewing and pleasing aesthetics without causing physiological issues[17]. Gidget outlined standards for ideal occlusion:[18]

1. Incorporate factors that reduce vertical stresses.
2. Maximize intercuspation with condyles in centric relation.
3. Enable horizontal movement of the jaw from a centric position until the teeth best suited to bear horizontal loads engage.

- **Balanced Occlusion:** Balanced occlusion involves simultaneous contact of anterior and posterior teeth during lateral movements, distributing lateral forces across all teeth and temporomandibular joint (TMJ). This aims to minimize harmful lateral forces on teeth, necessitating broad contact areas and intercuspal contact during movement. Limitations include uneven cusp-to-fossa relationships and challenges in achieving precise balance.[10]
- **Mutually Protected Occlusion** In mutually protected occlusion, posterior teeth protect anterior teeth in the centric position, and anterior teeth disengage posterior teeth during mandibular excursive movements. This setup maintains a vertical dimension, with canines guiding mandibular movement. It's contraindicated in horizontal masticatory cycles or compromised periodontium.[4,10,12]
- **Group Function Occlusion**:[19] Group function occlusion involves multiple contacts between maxillary and mandibular teeth during lateral movements, distributing occlusal forces among several teeth groups. It emphasizes long-axis loading, eliminates lateral interferences, and ensures proper interocclusal clearance.

- **Medial Positioned Lingualized Occlusion:**[16] In this occlusion, implants are placed medially, affecting occlusal contacts. As the ridge resorbs, occlusal contacts become more medial, influencing implant placement and restoration design. This concept aims to ensure axial loading and efficient mastication.
- **Occlusal Diagnosis:** Occlusal stability is crucial for implant-supported restorations, considering factors like loading, bone quality, and the adjacent teeth mobility. Complications may arise from excessive loading or occlusal irregularities, necessitating careful diagnosis and correction. Cantilever prostheses are used with caution, considering potential stress and occlusal forces.[14,20]

In summary, ideal occlusion for implant-supported prostheses involves careful consideration of various factors, including occlusal loading, implant placement, and restoration design, to ensure stability and longevity of the restoration.

VII. Occlusal Consideration

Premature occlusal contacts can lead to significant stress on implant-supported crowns, impacting their longevity and stability. Understanding the biomechanical principles involved is crucial for effective treatment planning and maintenance of dental implants.[5]

1. Stress Distribution: Stress is determined by force divided by the area of application. Premature occlusal contacts concentrate force on specific areas, increasing stress and potentially leading to complications.
2. Surface Area and Support: Splinting implant crowns together increases the surface area of support, distributing occlusal forces more evenly. Narrow implants may require additional support to compensate for their reduced surface area
3. Influence of Load Direction: Occlusal force direction plays a significant role in stress distribution. Vertical forces along the implant's long axis are preferred, as they reduce stress on crestal bone. Horizontal or angled forces increase stress, especially on narrow implants or cantilevered prostheses.
4. Complications and Warning Signs: Unlike natural teeth, implants lack a periodontal membrane to mitigate stress. Premature occlusal contacts can lead to irreversible bone loss and implant failure without warning signs like tooth sensitivity. Implant occlusal sensitivity indicates advanced complications.
5. Implant Configuration and Restoration Type: The configuration of implants and type of restoration impact stress distribution. Screw-retained prostheses may experience more offset loads compared to cement-retained ones. Proper placement and design can mitigate stress and enhance longevity.

Understanding these principles helps in designing occlusal schemes that minimize stress on implants, ensuring long-term success and patient satisfaction.

Bone biomechanics play a crucial role in the success of implant-supported prostheses, with considerations for how forces are applied to bone influencing treatment outcomes.[21]

1. Bone Strength and Load Distribution: Bone is strongest under compressive forces, weakest under shear, and less strong under tensile forces. Axial loads along the long axis of an implant distribute compressive stress effectively. However, angled loads increase tensile and shear stresses, which can weaken bone and affect implant stability.
2. Impact of Force Angle: The angle at which force is applied affects bone strength. Angled forces decrease bone strength limits, increasing stress around the implant body. Axial loading is essential to minimize negative effects, especially with increased force intensity or duration.
3. Minimizing Lateral Force: Occlusal designs should aim to reduce lateral forces, which increase tension and shear stresses on the crest of the ridge. Factors such as implant diameter, number of implants, and occlusal table width contribute to stress distribution and should be carefully considered in treatment planning.
4. Implant Configuration and Prosthesis Type: Wider implants distribute forces more effectively and reduce stress on the bone. Modifications in prosthesis type, such as switching from fixed to removable, can also help mitigate occlusal loads. Additionally, wider occlusal tables are recommended for improved masticatory efficiency, especially in unaesthetic regions.
5. Esthetic Considerations: Esthetics may influence occlusal table width, particularly in the maxillary arch, where preserving buccal cusps is essential for ideal appearance. However, in the mandibular arch, narrower occlusal tables are preferred to direct forces over maxillary implants effectively.

Understanding these biomechanical principles is essential for optimizing implant treatment outcomes, ensuring long-term success, and preserving both bone and prosthesis integrity.

VIII. Summary

The effectiveness and durability of endosteal dental implants are significantly influenced by the mechanical conditions they operate within, with occlusion playing a crucial role. Occlusion extends beyond mere tooth contact, encompassing the dynamic relationship between teeth, neuromuscular system, and TMJ, affecting the craniofacial environment. "Implant-protected occlusion" (IPO) is a specialized occlusal scheme for implant restorations, necessitating careful consideration before implementation. Key considerations for implementing IPO include eliminating premature contacts, ensuring mutually protected articulation, controlling occlusal table width, providing adequate load-bearing surface area, considering implant body orientation and load direction, addressing parafunctional activity, selecting appropriate occlusal materials, and designing prostheses to Favor the weaker arch. Understanding the unique stress dynamics between natural teeth and implants is crucial to minimizing implant complications. While the principles of occlusion for osseointegrated prostheses resemble gnathologic occlusion, specific recommendations vary. For fully bone-anchored bridge prostheses, mutually protected occlusion is recommended, with centric contacts on all posterior teeth and a 30µm clearance on anterior teeth. Overdentures typically employ fully balanced occlusion with lingualized occlusion, with posterior contacts and slight anterior clearance. In mixed dentition, where natural teeth and osseointegrated bridgework coexist, differences in sinking behavior during function necessitate careful adjustment of centric contacts. Occlusal surface design should avoid plane-to-plane contact, favoring point contact, especially cusp-to-fossa tripodal contact, and promoting anterior group function over canine guidance to distribute stress evenly. Connecting implant-supported prostheses to natural teeth remains debatable, with rigid connectors suggested over non-rigid ones to prevent issues like rotation-induced screw loosening or tooth depression. Post-prosthesis fabrication and occlusal adjustments are crucial to ensure proper function and aesthetics, adhering to adjustment guidelines.

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