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Research Article

OCCLUSION IN RESTORATIVE DENTISTRY- A REVIEW

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Abstract

Occlusion plays a critical role in restorative dentistry, significantly impacting the success and longevity of dental restorations. Proper occlusal alignment ensures functional harmony, patient comfort, and the longevity of both natural teeth and restorations. This review explores the fundamental concepts of occlusion in restorative dentistry, including the principles of occlusal analysis, diagnosis, and treatment planning. It highlights the importance of achieving balanced occlusion in various restorative procedures such as adhesive restorations, crowns, implant etc. Additionally, it discusses common occlusal issues encountered in restorative dentistry, including malocclusion, bruxism, and temporomandibular disorders (TMD), and outlines strategies for their management. Emphasis is placed on the integration of digital technology in occlusal assessment and the role of interdisciplinary collaboration in achieving optimal outcomes. By thoroughly examining contemporary practices and emerging trends, this review seeks to shed light on the significance of occlusion in improving the overall standard of restorative dental care.

Keywords: Restorative dentistry, Occlusal, Temporomandibular.

INTRODUCTION

In dentistry, occlusion is defined as the contact of the opposing dental arches when they are in contacts (static) and during various jaw movements (dynamic occlusion) (1). Occlusion refers to the relationship between upper and lower teeth. It has evolved from a simple point of contact to a complex understanding of how teeth, jaws, and muscles work together. In modern dentistry, occlusion is vital for diagnosis, treatment planning, and restorative procedures. Dentists cannot alter any tooth without impacting the final occlusion (2). Edward Angle's 19th-century malocclusion classification, still in use, began the study of occlusion (3). A contemporary perspective on occlusion considers the interconnectedness of teeth, the temporomandibular joint (TMJ), jaw muscles, and nerves, along with the relationship between the maxilla and mandible when they are functionally engaged during mandibular activity. This entire system is termed the "Masticatory or Stomatognathic System." The interactions and mutual dependencies of these elements establish the foundation of occlusion, ensuring that each mandibular movement is coordinated to optimize function while minimizing potential harm to any of the structures.

Fig. 1. Model showing ideal occlusal relation between maxilla and mandible

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Occlusion plays a vital role in restorative and prosthetic treatments, impacting TMDs which affect jaw joints and chewing muscles, causing pain and movement problems. A balanced neuromuscular system, with synchronized teeth, jaws, joints, and muscles, is crucial. Clinicians must ensure muscle balance post-surgery to prevent occlusal diseases and severe TMDs. Proper occlusion prevents issues like bite misalignment, uneven force distribution, tooth sensitivity, and TMDs. Restorative dentistry aims to restore teeth's original form and function, ensuring balanced occlusion to prevent clenching, bruxism, and temporomandibular dysfunction (4). Occlusion treatment should be customized to the specific needs of the masticatory system instead of following universal guidelines. This personalized approach improves treatment quality and success rates.

Balanced Occlusion

It refers to the simultaneous, bilateral contact of maxillary and mandibular teeth in both anterior and posterior areas during centric and eccentric positions. In natural teeth with fixed bases, balancing side contacts are harmful as they cause premature contacts, leading to occlusal wear, PDL breakdown, and TMJ issues. This concept is now outdated for natural teeth. However, principles such as condylar and incisal guidance, cusp height, curve of Spee, and plane of occlusion remain useful for restoring natural teeth.

Morphologic Occlusion

Orthodontists follow Morphologic occlusion, which involves ideal tooth-to-tooth contact. The mesiobuccal cusp of the upper first molar should align with the mesiobuccal groove of the lower first molar. This ideal alignment ensures stable teeth and prevents periodontal issues (5)

Ideal Occlusion

Orthodontists describe the "Ideal" Occlusion based on the works of Angle (1900) and Andrews (1972, 1989),

emphasizing specific anatomical relationships of the teeth and dental arches, focusing on static relations. An ideal occlusion is characterized by stable jaw relationships during centric, unrestricted glide with maintained occlusal contact between central relation and occlusion, smooth gliding occurs during excursive movements and occlusal guidance limited to the working side(5).

Figure 2.

Functional occlusion

In the 1970s, the "Dynamic Individual Occlusion" concept emerged, focusing on the health and function of each person's masticatory system rather than a specific occlusal configuration. This type of occlusion may deviate from the ideal but is well adapted to the individual's environment without causing pathology or dysfunction.

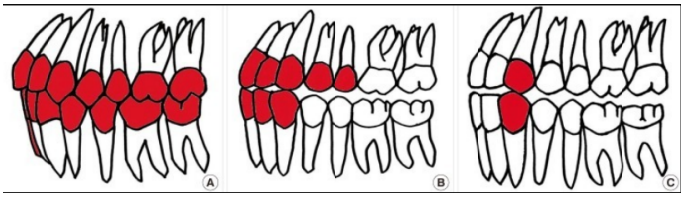

Figure 3. The sequence of functional occlusion (A) Centric occlusion. (B) Anterior guidance. (C) Canine guidance

Pathologic occlusion

It refers to a condition where significant disharmony between the teeth and TMJ causes symptoms requiring intervention. If the adaptive capacity of physiologic occlusion decreases, it can become pathologic (5).

Fundamentals concepts of occlusion

When performing restorative dental procedures, it's crucial to keep in mind five key principles. These fundamentals aid in understanding the stability of occlusion over time and identifying any instability. The goal is to assess and plan occlusion to reduce strain on the chewing system, including muscles, teeth, periodontal tissues, the TMJ, and dental restorations.

These principles of occlusion include

- Retruded Axis Position (RAP) or Centric Relation (CR) [Retruded Contact Position (RCP) = Inter Cuspal Position (ICP) around RAP]
- Mutually protected occlusion
- The importance of anterior guidance
- Non-working side interferences
- Posterior stability

Three of these concepts include anterior tooth contact: mutually protected occlusion, anterior guidance, and no nonworking or balancing side contacts. Losing anterior tooth contact can be very harmful to the patient.

RCP = ICP around RAP

Retruded Axis Position (RAP) refers to the position where the condyles are positioned at the most posterior, superior, and central point in the glenoid fossa. Despite debates, RAP is considered a reproducible area with relaxed muscles. It indicates the mandible's position to the maxilla, crucial before restorative dentistry. RAP is stable with relaxed muscles and a bone brace, ideal for advanced restorative work (6). In Retruded Contact Position (RCP), the upper and lower teeth first touch with the condyles in Retruded Axis Position (RAP). Around 10% of patients close into Intercuspal Position (ICP) while in RAP, whereas 90% achieve maximum intercuspation slightly forward. Tooth contact and proprioceptive feedback guide the mandible from RCP to ICP (7). Centric relation (CR) refers to the maxilla-mandibular relationship where the condyles are in the most anterior-superior position in the glenoid fossae. In CR, only rotational movement of the condyles is possible. Unlike intercuspal position, CR is a mandibular position independent of tooth contact.

Mutually protected occlusion and anterior guidance

In maximum intercuspation, the back teeth safeguard the front teeth. During forward movement, the front teeth meet at the incisal edges, shielding the canines and back teeth from contact. In side-to-side movement, the upper and lower canines touch, protecting both the front and back teeth, without any contact between them (8). Posterior teeth handle vertical forces, protecting anterior teeth. Anterior teeth manage horizontal forces, protecting posterior teeth. Anterior teeth are not built to withstand vertical loads (9).

The importance of anterior guidance

The unique relationship between anterior teeth and the TMJ fulcrum protects posterior teeth during function. Anterior guidance reduces muscle activity in excursive positions, aligning with tooth function and the muscular system, thus harmonizing with the "Envelope of Function." It forms from the contact between mandibular and maxillary anterior teeth surfaces, without interfering with mandible movements. Proper anterior guidance is crucial for designing occlusal schemes and solving occlusal issues.

Non-working side contacts (interferences)

During lateral movement, the non-working side typically has no tooth contact. The initial contact on the non-working side is referred to as non-working side interference. When restoring opposing teeth, it's crucial to avoid creating occlusal disharmony, which can cause TMJ issues like clicking or muscle pain. For example, extracting a lower left second premolar can cause the first molar to incline, changing occlusion and causing interference (10).

Posterior stability

When restoring a posterior tooth, its occlusal structure should align with that of the adjacent teeth. For maxillary posterior teeth, adjust the buccal incline of palatal cusps; for mandibular posterior teeth, adjust the palatal incline of buccal cusps (11). Posterior teeth's occlusal stability is crucial for the masticatory system to function effectively (12).

Molar disocclusion

When individuals with normal occlusions repeatedly move their mandible laterally, their movement paths vary because of the flexibility of the articular disc. Deviation averages: 0.2 mm in centric relation, 0.3 mm in working movements, and 0.8 mm in protrusive and nonworking movements (13). To prevent occlusal interferences and non-axial forces on molars during eccentric movements, molar disocclusion should match or exceed the observed mandibular deviations.

Condylar guidance

Important elements of condylar guidance that influence posterior teeth occlusion include the inclination of the protrusive condylar path and the lateral movement of the mandible. The protrusive condylar path inclination differs among individuals, averaging 30.4 degrees relative to the horizontal reference plane (43 mm above the edge of the upper central incisor). A steeper protrusive inclination permits longer cusp height, whereas a shallower inclination necessitates shorter cusp height (14).

Importance of occlusion in restorative dentistry

Dental restorations play a crucial role in occlusion and are essential in restorative dentistry. They often involve the occlusal surfaces of teeth. Restorative procedures can alter occlusion, potentially causing issues. Dentists aim to avoid these complications for successful outcomes. Effective occlusion management ensures the longevity of restorations and prostheses, patient comfort, occlusal stability, and absence of complications (15).

Forces acting on dentition

One important aspect of physics in dentistry involves analyzing the forces applied to teeth and dental restorations. Teeth experience different forces during normal activities. Biomechanics studies how these forces interact with the shape and structure of teeth, their supporting structures, and the mechanical properties of tooth components and restorative materials. According to dental literature, biting forces on teeth have been measured, with maximum forces ranging from 200 to 2440 Newtons (45 to 550 pounds).

Biomechanical Unit

The standard biomechanical unit involves the

1. Restorative material
2. Tooth structure, and
3. Interface between the restoration and tooth

The importance of considering three structures in the biomechanical unit is to detect stresses that may cause unwanted fractures or debonding. The restorative material may be strong enough to resist fracture, but the interface or tooth structure may not be.

Principles of biomechanics

Stress transfer and the resulting deformations of structures are principally governed by:

1. The elastic limit of the materials
2. The ratio of the elastic moduli involved
3. Thickness of the structures

Approaches to occlusal schemes in restorative dentistry

Restorations should be created and positioned to seamlessly integrate with the stomatognathic system, ensuring no occlusal interferences. Ideally, there should be stable posterior occlusion with smooth protrusive and lateral mandibular movements, although this isn't always possible. Thus, occlusion should be evaluated before any restorative procedures that could modify it. After the assessment, the appropriate occlusal scheme approach for the restorations must be determined (11)

These can be:

1. Conformative approach
2. Reorganised approach

Conformative approach

In this method, the occlusal arrangement is determined by the patient's current intercuspal position, and the new restorations are crafted to fit the existing jaw relationships. Ideally, analyzing the occlusion is necessary to ensure it meets a specific standard. However, this standard isn't always clearly defined, particularly concerning occlusal contacts and the nature and stability of those contacts.

The approach includes two situations:

- Occlusion is left unchanged before tooth preparation, but minor adjustments can be made to restorations, like removing non-working side contacts.
- Occlusion is modified by making localized adjustments to the teeth's occluding surfaces before tooth preparation. This includes removing deflective contacts on the tooth to be restored, shortening the opposing cusps, and eliminating non-working side interferences (16,17)

Situations where conformative approach can be used:

1. The patient's occlusion is ideal: centric occlusion is within 1 mm of centric relation, anterior guidance is at the front, and there are no posterior interferences.
2. The patient's occlusion is perfect: centric occlusion is within 1 mm of centric relation, with anterior guidance and no posterior interferences.
3. There is an absence of any TMD. If the patient has an existing TMD, then a decision has to be taken if it needs to be treated first, since it is possible that the treatment of this condition could result in changes to the patient’s occlusion. (18)

Consequences of not conforming to correct occlusion

Premature contacts on restorations or teeth can cause fractures. Patients might adjust their mandibular posture, leading to anterior tooth wear. Altered occlusion can crack previously sound teeth. High restorations cause discomfort, toothache, headaches, muscle soreness, and TMJ pain. Inaccuracies in impressions, occlusal records, and lab mounting lead to ill-fitting restorations. Poorly made provisional restorations result in drifting and overeruption, causing high and ill-fitting restorations.

Reorganised approach

This method is used if the current occlusal scheme is unsatisfactory for the restorative plan, specific problems require occlusion reorganization, or extensive treatment changes the occlusal scheme (19). Various alternative occlusal schemes are detailed in the literature, including balanced occlusion (bilaterally balanced occlusion) and unilaterally balanced occlusion. The first is suggested for complete denture prosthodontics to ensure denture stability during dynamic movements.

Occlusal considerations in adhesive restorations

A conformative approach is typically adopted in cases involving adhesive or bonded restorations unless extensive occlusal corrections or full-mouth rehabilitation using adhesive restorations are required (20). Using this approach preserves the patient's existing occlusal status while ensuring that the restoration blends into the dentition. The interface between the restoration and the healthy tooth structure should be designed in such a way that any contact with the working cusp should be avoided to reduce the stress concentration. Material properties like hardness and fracture toughness are key in choosing the restoration type based on the patient's ability to withstand forces. Porcelain offers great esthetics but can fracture under heavy occlusal loads, while metals and high-strength ceramics like zirconia provide better durability. Choosing materials with sufficient strength helps prevent restoration failure in high-stress areas (20). When working with zirconia, extend the substructure to the incisal edge or cusp for added support. This helps to evenly distribute occlusal loads and reduces the risk of veneer chipping or delamination. For restorations on the palatal surfaces of upper front teeth, a custom-made incisal guide might be required to ensure precise guidance during functional movements and minimize interferences (21).

Effects of occlusion on restoration longevity

Several factors affect the longevity of dental restorations, such as the restoration size, tooth position, patient's caries index, material choice, moisture control, and various patient- and clinician-related aspects. (22) Among all the above-mentioned factors occlusion is one of the most significant one which is often overlooked. Restorations that match the existing dentition tend to last longer than those with high occlusion or interferences during excursive movements, which experience unfavorable forces (23). It's crucial to align restorations with the patient's natural occlusal pattern to minimize stress and avoid premature failure. Conversely, restorations with improper occlusal contacts can cause localized stressconcentration, leading to microcracks formation or debonding of the restoration. Material selection plays a crucial role in determining how restorations withstand occlusal loads. Amalgam has long been favored for patients with parafunctional habits or heavy occlusal forces, as well as in cases where the occlusal load falls directly on the restoration (24). Due to advancements in material science, composite resin has become a viable choice for posterior restorations, offering durable bonds and the capacity to withstand occlusal forces. A meta-analysis by Heintze and Rousson found a 5% failure rate from fractures and about 12% noticeable wear over 10 years (25,26). When the occlusal load surpasses the material's capacity, the restoration may crack or fracture. Multi-surface restorations, like class II or class IV, are especially prone to fractures due to their larger surfaces and intricate occlusal relationships (27,28). When restoring multiple surfaces, it's important to consider material selection and ensure proper occlusal balance to minimize stress at contact points.

Occlusal trauma and its effects on restorations

Occlusal trauma, or trauma from occlusion, refers to injury to the attachment apparatus that results from excessive occlusal force (29). Periodontal health is affected by the forces exerted on teeth. Moderate occlusal forces can enhance it by thickening the lamina dura and reorganizing the bony trabeculae. Conversely, excessive forces can cause tissue damage, resulting in increased tooth mobility, widened periodontal ligament spaces, and bone resorption. Before initiating restorative treatment, it's essential to conduct a comprehensive clinical examination to ensure functional harmony in the masticatory system. This examination should evaluate the stability of the joint position, tooth alignment, the direction and intensity of occlusal forces, and any indications of occlusal overload (30). Identification of any pre-existing occlusal overload can prevent the possible complications, such as restoration fracture, debonding or even periodontal destruction.

Occlusal recording and reconstruction

Several articulators exist for occlusal recording and reconstruction. The Denar semi-adjustable articulator with a face-bow is commonly used for complex restorative treatments.

Occlusion indicating materials and techniques used in the past and present:

Various occlusal recording materials.

1. Alginate Impression Material	6. Transparent acetate sheets.	11. Black Silicone.
2. Mylar paper strip.	7. Wax.	12. High Spot Indicator
3. Polyether rubber impression bites.	8. Wax Articulation Paper.	13. Occlusal Sprays
4. Silicon Putty.	9. Silk Strips	14. Photo occlusion
5. Typewriter Ribbon	10. Foils	15. Occlusal Sonography
16. T-Scan	17. Pressure Sensitive Films	

Comparison of Tools and Devices for Occlusal Analysis: Features and Limitations (31)

Device / Tool	Key features	Limitations
Occlusal Sonography	Identifies occlusal issues by listening to the sounds produced during closure.	Sound variation depending on closure force limits accuracy.
T scan	Utilizes a color spectrum from blue to red to depict occlusal forces, helping to diagnose occlusal trauma, identify premature contact, and achieve occlusal balance during treatments.	Film thickness of 0.1 mm, thicker than articulating paper and shimstock, limiting precision.
OccluSense	A 60-micron thick wireless sensor with app-based data visualization that requires daily function tests to ensure proper operation.	It doesn't have scientific proof for reliability, repeatability, and accuracy, unlike T-Scan's 36-year track record.
Articulating Paper Strips and Shimstock	Articulating paper, available in various thicknesses, leaves dye marks to indicate occlusal force. Shimstock, at 8-12 microns thick, offers a more precise way to detect occlusal high points.	Articulating paper thickness (40 microns) exceeds patients' occlusal tactile sensitivity (8-10 microns), leading to inaccuracies.

Digital Occlusal analysis

Various digital technologies have been introduced overtime that have made assessment and rehabilitation of occlusion very convenient. With the advances in computer technology, digital dental models are now being widely used for diagnosis and treatment planning for occlusal adjustments. Assessment with the help of these technologies, reduces the chance of errors, provides proper diagnosis of the problem, and helps in appropriate treatment planning.

These technologies include

- Intra-oral scanners
- Computerized occlusal analysis T- Scan
- Computerized Electromyography system
- Virtual articulators

Occlusal Interferences

Undesirable contacts between opposing teeth, known as occlusal interferences, can lead to mandibular displacement on either the working or non-working side during lateral movements. It is important to identify these interferences before performing any restorative treatment.

There are various types of Occlusal interferences:

- Centric interferences
- Working interferences
- Non-working interferences
- Protrusive interferences

In a reorganized approach for restorative rehabilitation, lateral guidance should come from the canines, without occlusal interferences on the working or non-working side. Non-working side contacts without pathology signs are not necessarily interferences. Such contacts might be present in patients with malocclusions or non-ideal natural occlusal schemes. Excursive and protrusive contacts, marked with articulating paper, should be smooth and continuous. Any irregular or broken appearance may indicate interference on the tooth or elsewhere in the oral cavity.

Selective grinding

Defined as "modification of the occlusal forms of the teeth by grinding according to a plan. The modification of the occlusal forms of teeth by grinding at selected places marked by spots made by articulating paper, or marked by parts of the teeth cutting through a thin layer of wax placed over the teeth".

Occlusal dysfunction

The dictionary defines disease as an impairment of the normal state of a living body, affecting its vital functions and showing signs and symptoms. Negative effects of occlusion are often called "problems" or "conditions," but based on this definition, "disease" is a more fitting term, leading to "occlusal disease." Occlusal disease results from a mix of inherent defects or malocclusion, environmental factors or maladjusted restorations, and abnormal masticatory activities. These lead to degeneration and dysfunction of the masticatory system, shown by signs and symptoms. Both conditions must coexist for occlusal disease to occur. As a perfectly balanced bite is rare, and parafunctional activities can be worsened by stress and certain drugs, occlusal disease is common and chronic.

Basic mechanism for tooth surface deformation

According to Grippo et al, it is now apparent that deformation of tooth structure results from three basic physical and chemical mechanisms that can act alone or in combination (32)

1. Stress results in compression, flexure, and tension. It can produce microfracture and abfraction as a dental manifestation.
2. Friction includes abrasion from exogenous material and attrition, which is endogenous and results from empty mouth bruxing and parafunction. The end point of both is wear of tooth surfaces.
3. Corrosion is the result of chemical or electrochemical degradation.

The interplay of these three fundamental mechanisms typically results in accelerated structural damage to teeth. Consequently, the structural deformation of teeth is generally multifactorial. Nonetheless, occlusal overload frequently emerges as the primary concern that must be addressed when devising a treatment plan for severely damaged tooth structures.

Various etiologies for occlusal dysfunction include:

- Attrition
- Abrasion
- Erosion – Endogenous and exogenous
- Abfractions
- Splayed teeth
- TMD

Occlusion and its effect on Temporomandibular disorders (TMD)

Clinicians and researchers have considered for many years occlusion as one of the major direct and/or indirect etiological factors causing temporomandibular disorders (TMDs) (33). TMD refers to a group of conditions that cause dysfunction and pain in the masticatory muscles, temporomandibular joints (TMJs), and the surrounding tissues. The cause-effect relationship between occlusion and TMD has been based for a long time on the observation of the anatomic connection between teeth position and jaw functions, and on the higher prevalence of TMD in individuals with dental malocclusion compared with the general population (34). Numerous studies have examined how occlusion and malocclusion might contribute to the emergence of TMD signs or symptoms. For example, a recent online study found that over half of the current websites linked TMD to occlusal issues or malocclusion and suggested treating occlusal changes to relieve TMD (35). However, recent studies contradict this association between occlusion and TMD, attributed mainly to the lack of scientifically valid evidence. A literature review published regarding the association between TMD and occlusion reported an absence of a disease-specific association, and concluded that there is no ground to hypothesize a major role for dental occlusion in the pathophysiology of TMDs (36). However, recent scientific trend has turned the focus of etiology of TMD from a biomedical to a more complex multifactorial biopsychosocial model, which includes biological, psychological, and social factors (37).

Conclusion

In conclusion, occlusion plays a critical role in restorative dentistry, as it directly determines the success and longevity of dental restorations. Proper occlusal assessment and management are essential to ensure optimal function, comfort, and aesthetics for patients. By understanding the complexities of occlusion and incorporating precise techniques in treatment planning and execution, dental professionals can achieve more predictable and favorable outcomes. Continual advancements in occlusal analysis technologies and materials further enhance the ability to provide high-quality restorative care, ultimately contributing to improved patient satisfaction and oral health.

REFERENCES

1. Sturdevant's Art & science of operative dentistry – 7Th edition – Roberson, Heyman & Swift.
2. Nelson SJ. Wheeler's dental anatomy, physiology and occlusion-e-book. *Elsevier Health Sciences;* 2014 Sep 30.
3. Davies S. What is occlusion? In A Guide to Good Occlusal Practice 2022 Jun 4 (pp. 1-22). Cham: Springer International Publishing.
4. Fasbinder DJ, Poticny DJ. Accuracy of occlusal contacts for crowns with chairside CAD/CAM techniques. *International Journal of Computerized Dentistry.* 2010 Jan 1;13(4):303-16.
5. Okeson JP. Management of Temporomandibular Disorders and Occlusion. Chapter 5, 5th ed. 2001;95-110.
6. Tipton P. Restoration fundamentals. Scottish Dental Magazine. 2013
7. Hersh HA. Current Concepts in Occlusion, McGill University (Canada). 1971
8. Tiwari B, Ladha K, Lalit A, Dwarakananda Naik B. Occlusal concepts in full mouth rehabilitation: an overview. *J Indian Prosthodont Soc.* 2014 Dec;14(4):344-51. doi: 10.1007/s13191-014-0374-y. Epub 2014 Jun 25. PMID: 25489156; PMCID: PMC4257939.
9. Song MY, Park JM, Park EJ. Full mouth rehabilitation of the patient with severely worn dentition: a case report. J Adv Prosthodont. 2010 Sep;2(3):106- 10. doi: 10.4047/jap.2010.2.3.106. Epub 2010 Sep 30. PMID: 21165279; PMCID: PMC2994694
10. Singh A, Sangur R, Rao BL, Mahajan T. A clinical study to determine the pattern of occlusal contacts in lateral positions and its validity in classifying guidance patterns. *J Indian Prosthodont Soc.* 2013 Jun;13(2):101-7. doi: 10.1007/s13191-012-0210-1. Epub 2012 Nov 9. PMID: 24431718; PMCID: PMC3634949.
11. McCullock AJ. Making occlusion work: 2. Practical considerations. Dent Update. 2003 May;30(4):211-6, 218-9. doi: 10.12968/denu.2003.30.4.211. PMID: 12830699.
12. Bakke M. Mandibular elevator muscles: physiology, action, and effect of dental occlusion. Scand J Dent Res. 1993 Oct;101(5):314-31. doi: 10.1111/j.1600-0722.1993.tb01127.x. PMID: 8248735.
13. Oliva RA. Three-dimensional study of mandibular movement using an automatic electronic measuring system. *J. Gnathology.* 1986; 5:115-82.
14. Hobo S. A kinematic investigation of mandibular border movement by means of an electronic measuring system. Part III: rotational center of lateral movement. *The Journal of Prosthetic Dentistry.* 1984 Jul 1;52(1):66-72.
15. McCullock AJ. Making occlusion work: I. Terminology, occlusal assessment and recording. Dent Update. 2003 Apr;30(3):150-7. doi: 10.12968/ denu.2003.30.3.150. PMID: 12743913.
16. Foster LV. Clinical aspects of occlusion: 1. Occlusal terminology and the conformative approach. *Dent Update.* 1992 Oct;19(8):345-8. PMID: 1291384.
17. Celenza FV, Litvak H. Occlusal management in conformative dentistry. *J Prosthet Dent.* 1976 Aug; 36(2):164-70. doi: 10.1016/0022-3913(76)90138-4. PMID: 1068280
18. Davies SJ, Gray RJ, Qualtrough AJ. Management of tooth surface loss. *Br Dent J.* 2002 Jan 12;192(1):11-6, 19-23. doi: 10.1038/sj.bdj.4801278. PMID: 11852896.
19. Davies SJ, Gray RM, Whitehead SA. Good occlusal practice in advanced restorative dentistry. *Br Dent J.* 2001 Oct 27; 191(8):421-4, 427-30, 433-4. doi: 10.1038/sj.bdj. 4801200. PMID: 11720016
20. Biagioni A, Pecciarini M, Discepoli N, et al. J Osseointegration. The role of occlusion on full mouth rehabilitation by adhesive partial crowns. A systematic review. 2020;12:161–166.
21. Warreth A, Doody K, Al-Mohsen M, Morcos O, Al-Mohsen M, Ibieyou N. Fundamentals of occlusion and restorative dentistry. Part II: occlusal contacts, interferences and occlusal considerations in implant patients. https://pubmed.ncbi.nlm.nih.gov/26665905/ *J Ir Dent Assoc.* 2015;61:252–259.
22. Mohan B, Sihivahanan D. Occlusion: the gateway to success. *J Interdiscip Dent.* 2012;2:68–77
23. Asaad YM, Alhudaithi MK, Alazraqi MS, et al. The impact of occlusal forces on the longevity of restorations. *Int J Community Med Public Health.* 2023;10:3899–3903.
24. Gil FJ, Espias A, Sánchez LA, Planell JA. Comparison of the abrasive wear resistance between amalgams, hybrid composite material and different dental cements. *Int Dent J.* 1999; 49:337–342. doi:10.1111/j.1875-595x.1999.tb005 34.x.
25. Lutz F, Phillips RW, Roulet JF, Setcos JC. In vivo and in vitro wear of potential posterior composites. *J Dent Res.* 1984;63:914–920. doi: 10.1177/00220345840630062201.
26. Heintze SD, Rousson V. Clinical effectiveness of direct class II restorations - a meta-analysis. *J Adhes Dent.* 2012;14:407–431. doi: 10.3290/j.jad.a28390.
27. Opdam NJ, van de Sande FH, Bronkhorst E. et al. Longevity of posterior composite restorations: a systematic review and meta-analysis. *J Dent Res.* 2014;93:943–949. doi: 10.1177/0022034514544217.
28. . Beck F, Lettner S, Graf A, et al. Survival of direct resin restorations in posterior teeth within a 19-year period (1996-2015): a meta-analysis of prospective studies. *Dent Mater.* 2015; 31:958–985. doi: 10.1016/j.dental.2015. 05.004.
29. American Academy of Periodontology: Glossary of periodontal terms. [Oct; 2024]. 2024
30. Srivastava A, Chaubey KK, Agarwal RR, Agarwal A, Bharali J. Trauma from occlusion: a review article. https:// ijdmsrjournal.com/issue_dcp/Trauma%20from%20Occlusion%20A%20Review%20Article.pdf. Int J Dent Med Sci Res. 2021;3:612–621.
31. Aldowish AF, Alsubaie MN, Alabdulrazzaq SS, Alsaykhan DB, Alamri AK, Alhatem LM, Algoufi JF, Alayed SS, Aljadani SS, Alashjai AM, Alamari AS. Occlusion and Its Role in the Long-Term Success of Dental Restorations: A Literature Review. Cureus. 2024 Nov 7;16(11):e73195. doi: 10.7759/cureus.73195. PMID: 39651022; PMCID: PMC11624512.

32. Grippo JO, Simring M, Schreiner S: Attrition, abrasion, corrosion and abfraction revisited: a new perspective on tooth surface lesions. *J Am Dent Assoc.,* 135(8):1109-1118, 2004.
33. Leeuw R, Klasser G, editors. American Academy of Orofacial pain. Orofacial pain: guidelines for assess ment, diagnosis, and management. Orofacial pain: guidelines for assessment, diagnosis, and management. IL, USA: Qui tessence Publishing Co Inc; 2018. p. 133e41.
34. Shroff B. Malocclusion as a cause for temporomandibular disorders and or thodontics as a treatment. *Oral Maxillofac Surg Clin North Am* 2018;30:299e302.
35. Desai B, Alkandari N, Laskin DM. How accurate is information about diagnosis and management of temporomandibular disorders on dentist websites? *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2016;122:306e9.
36. Manfredini D, Lombardo L, Siciliani G. Temporomandibular disorders and dental occlusion. A systematic review of association studies: end of an era? J Oral Rehabil. 2017 Nov;44(11):908-923. doi: 10.1111/ joor.12531. Epub 2017 Jul 2. PMID: 28600812.
37. Suvinen TI, Reade PC, Kemppainen P, Könönen M, Dworkin SF. Review of aetiological concepts of temporomandibular pain disorders: Towards a biopsychosocial model for integration of physical disorder factors with psychological and psychosocial illness impact factors. *Eur J Pain* 2005;9:613e33.

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