

# Occlusal Considerations for Implant-Supported Prosthesis



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**Disclaimer:** Participants must always be aware of the hazards of using limited knowledge in integrating new techniques or procedures into their practice. Only sound evidence-based dentistry should be used in patient therapy.

## Conflict of Interest Disclosure Statement

- Dr. Ahuja reports no conflicts of interest associated with this course. She has no relevant financial relationships to disclose.

## Short Description

A well-designed occlusion for an implant-supported prosthesis minimizes stresses on implants, preserves marginal bone and soft tissues, and prevents implant and prosthetic failure.

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## Overview

A well-designed occlusion for an implant-supported prosthesis minimizes stresses on implants, preserves marginal bone and soft tissues, and prevents implant and prosthetic failure. Unlike natural teeth, implants lack a periodontal ligament, requiring specific occlusal modifications to ensure long-term success. Occlusion is fundamental to prosthodontic rehabilitation, influencing not only the oral structures but also the overall health. Occlusal disharmonies can impact the temporomandibular joints, muscles of mastication, and even systemic health.

## Learning Objectives

**Upon the completion of this course, the dental professional should be able to:**

- Learn the biophysiological differences between natural teeth and dental implants, and how these differences influence occlusion and load distribution.
- Define and critically evaluate occlusal overload, emphasizing its clinical significance in implant restorations.
- Identify and assess risk factors that predispose implant-supported prostheses to occlusal overload.
- Apply preventive and management strategies to eliminate occlusal overload.
- Describe appropriate occlusal principles for single implants, implant-supported bridges, and full-arch prostheses.
- Develop occlusal schemes that promote

- implant longevity, stability, and function.
- Integrate occlusion-driven planning into the surgical placement and prosthetic restoration of dental implants.

## Introduction

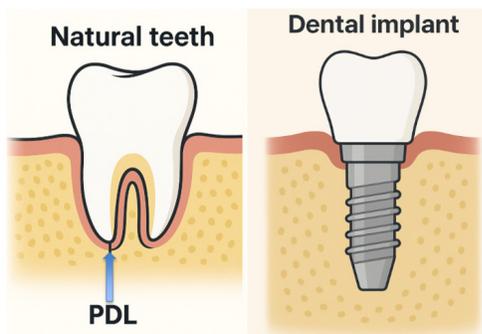
According to the Glossary of Prosthodontic Terms, occlusion is defined as “the static relationship between the incising or masticatory surfaces of the maxillary and mandibular teeth or tooth analogues.”<sup>1</sup> Occlusion represents the contact between opposing teeth/restorations. It plays a critical role in achieving optimal masticatory function and prosthetic outcome.<sup>2,3</sup>

Occlusion is also a crucial component associated with the success and long-term survival of implants and implant prostheses.<sup>4</sup> The functional adaptability of implants is different from that of natural teeth, this is primarily attributed to the absence of the periodontal ligament.<sup>5,6</sup> Proper management of occlusal forces is critical for achieving successful osseointegration (in cases of immediate loading), maintaining peri-implant bone health, and preventing mechanical or biological complications.<sup>5,6</sup> While occlusal loading is considered clinically critical, the scientific evidence investigating the effect of occlusal loading on implant outcomes is limited. Graves et al. reported that occlusal overload may negatively affect peri-implant tissues but emphasized the need for further studies to corroborate their findings.<sup>7</sup> Sheridan et al. emphasized the importance of proper management of occlusal forces for improving the long-term success of implants.<sup>8</sup> Kim et al. suggested that biomechanical risk factors such as large cantilevers, parafunctional habits, premature contacts, and improper occlusal design may affect the long-term health of the implant.<sup>9</sup>

A systematic review by Goldstein et al. evaluated nearly 1,500 articles but found only 15 studies specifically focusing on implant occlusion.<sup>10</sup> Similarly, Sadowsky et al. reported that there were no established guidelines for implant occlusion.<sup>11</sup> Since high-quality studies on implant occlusion are scarce, the philosophies derived from natural dentition are often applied to implants to optimize occlusal stability, preserve peri-implant health, and enhance the long-term success of implant-supported restorations.<sup>10</sup>

## Biophysiological Differences Between Natural Teeth and Dental Implants

The periodontal ligament surrounding the natural teeth protects them from occlusal overload by providing cushioning, shock absorption, proprioception, thermal feedback, and functional adaptability.<sup>5,6,8,9</sup> Implants lack the periodontal ligament (PDL) (Figure 1) as they form a rigid connection with the bone.<sup>5,6,8,9</sup> Thus, occlusal forces that are well tolerated by natural teeth may not be tolerated by the implants due to the biophysiological difference between them.<sup>5,6,8,9</sup> It is therefore critical to understand these differences to achieve or establish an optimal occlusion in implant-supported restorations. They include the following:

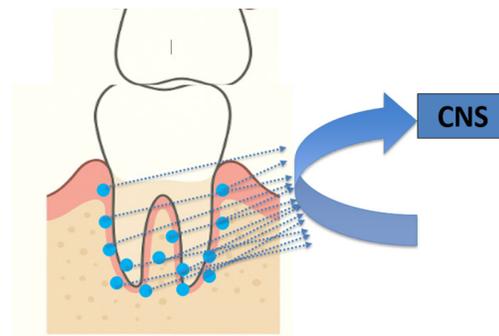


**Figure. 1** Natural teeth are surrounded by PDL (Left). Implants are directly attached to the alveolar bone (Right)

*Image Source: AI-generated image*

**Proprioception:** Natural teeth have mechanoreceptors that provide proprioception, which conveys sensory input regarding occlusal forces to the central nervous system (CNS) (Figure 2).<sup>5,6</sup> This permits optimal regulation of occlusal forces and protects against excessive occlusal loading. The occlusal perception threshold between natural teeth is approximately 20  $\mu\text{m}$ ; In contrast, implants demonstrate markedly reduced occlusal perception thresholds: around 48  $\mu\text{m}$  between a tooth and an implant, 64  $\mu\text{m}$  between two implants, and up to 108  $\mu\text{m}$  in implant-supported overdentures.<sup>4,5</sup> This reduced sensitivity is associated with the absence of proprioceptive receptors around implants. Implants have osseoperception Q2, a less

precise feedback mechanism mediated by surrounding bone and soft tissues.<sup>4,5</sup>



**Figure. 2** PDL mechanoreceptors convey sensory input to the CNS

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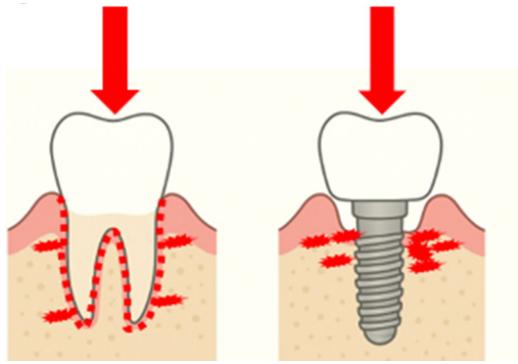
**Thermal feedback:** Natural teeth demonstrate cold sensitivity when subjected to heavy occlusal forces.<sup>14</sup> This adaptive and sensory capacity is absent in implants.

**Signs of trauma:** When natural teeth are subjected to occlusal trauma, they exhibit early signs such as fremitus, hyperemia, cervical abfraction (Figure 3), PDL widening, and radiographic density changes.<sup>12</sup> Implants, on the other hand, do not display any warning signs; by the time the patient complains of pain, the occlusal overload has already caused irreversible tissue damage.<sup>5,6</sup>



**Figure. 3** Cervical abfraction lesions on the maxillary incisors

**Load transmission:** The PDL acts as a shock absorber, thereby decreasing the stresses transmitted to the bone, particularly in the crestal region.<sup>5</sup> Since Implants lack the PDL, there is no dissipation of occlusal forces; instead, high impact forces are directly transmitted to the surrounding bone (Figure 4).



**Figure. 4** The PDL helps dissipate occlusal stresses; implants lack a PDL and transmit forces directly to bone.

*Image Source: AI-generated image*

In addition, the long axis of the natural tooth (crown and root) is generally aligned with the alveolar bone.<sup>13</sup> However, implants are often placed more lingually and apically than the natural teeth they replace due to bone resorption following tooth loss.<sup>13</sup> Thus, the point of application of force on an implant prosthesis usually lies away from the crestal ridge that anchors the implant, thereby creating unfavorable load transmission.<sup>13</sup>

**Mobility:** Natural teeth move 25-100  $\mu\text{m}$  axially and 56-150  $\mu\text{m}$  horizontally under functional load, compared to implants that demonstrate reduced mobility in the range of 3-5  $\mu\text{m}$  vertically and 10-50  $\mu\text{m}$  horizontally.<sup>14</sup> This allows natural teeth to adapt to occlusal forces through minor intrusion or rotational movement, whereas implants transmit the entire load directly to the bone-implant interface.<sup>14</sup> Furthermore, mobility in natural teeth may be reduced or reversed upon elimination of the traumatic load, while implants lack this adaptive response.<sup>15</sup>

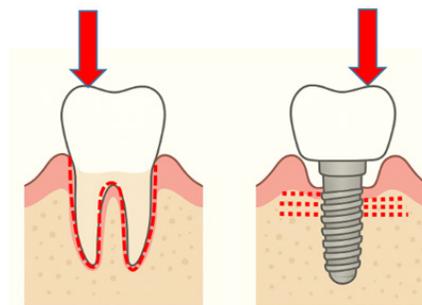
**Type of movement under functional loading:**

Under loading, the movement of natural teeth is nonlinear and occurs in two phases: an initial phase associated with periodontal ligament displacement, followed by a secondary phase dependent on the elastic deformation of the alveolar bone.<sup>14</sup> In contrast, implant movement is linear, lacking the initial phase, and consisting only of a secondary elastic phase.<sup>14</sup> Owing to the compressibility and adaptability of the PDL,

natural teeth are better able to withstand occlusal forces than implants.<sup>9,14</sup>

**Fulcrum of lateral forces and rotational capacity:** Lateral stresses are less detrimental to natural teeth as they are dispersed along the entire root length.<sup>9</sup> This is associated with the fulcrum (of lateral forces) being positioned in the apical third of the root.<sup>5</sup> Implants, on the other hand, have their fulcrum located at the crestal bone, thereby resulting in a concentration of stresses at the bone-implant interface (Figure 5).<sup>5,9</sup>

When subjected to lateral loads, natural teeth rotate slightly around the apical third of the root to distribute forces, whereas implants lack this rotational capacity, resulting in stress concentration at the crestal bone and an increased risk of crestal bone loss.<sup>9</sup>



**Figure 5.** Lateral stresses are dispersed along the entire root length (left); Lateral stresses are concentrated at the bone-implant interface (right).

*Image Source: AI-generated image*

**Size:** The diameter of natural teeth is larger than the diameter of implants, and their anatomical form is naturally configured to withstand functional loads.<sup>5,6</sup> For example, canine roots are designed to withstand lateral forces, while molar roots are configured to manage vertical (axial) loads.<sup>15</sup> In contrast, implant dimensions are dictated primarily by bone availability rather than occlusal load optimization.<sup>5,6</sup>

**Cervical cross-sectional anatomy:** The cervical cross-sectional anatomy of natural teeth is adapted to the direction and amount

of stress, which helps dissipate the lateral forces. Implants, on the other hand, have a circular design that facilitates their surgical placement but directs load on the crestal bone.<sup>5,6</sup>

**Elastic modulus:** Dentin has an elastic modulus similar to that of bone, which helps with optimal stress distribution. However, Titanium (used for implant fabrication) is 5-10 times stiffer than bone and therefore transmits greater stresses to peri-implant bone.<sup>5,6</sup>

**Passive eruption and positional changes:** Natural teeth exhibit passive eruption and continuous positional changes throughout life.<sup>6</sup> However, implants remain static, which may increase the risk of occlusal imbalance if not regularly monitored.<sup>6</sup>

### Occlusal Overload

According to the Glossary of Oral and Maxillofacial Implants, occlusal overload is defined as “the application of occlusal loading, through function or parafunction, in excess of what the prosthesis, implant component, or osseointegrated interface is capable of withstanding without structural or biologic damage.”<sup>16</sup> The rigid bone-implant interface, combined with the crestal fulcrum (generated by lateral forces), concentrates stress in the crestal region, thereby subjecting peri-implant bone to excessive loading.<sup>5,9</sup> Several studies have suggested that occlusal overload in implants may result in biological complications such as marginal bone loss and implant failure, and/or mechanical complications such as screw loosening or fracture, veneering material failure, prosthesis fracture, and/or implant fracture.<sup>17-19</sup>

However, the direct association between implant occlusal overload and peri-implant tissue loss remains controversial due to the lack of long-term clinical studies and randomized controlled trials in humans.<sup>4,20,21</sup> Current scientific evidence suggests that occlusal overload may contribute to peri-implant tissue loss in the presence of inflammation; however, this relationship is less significant in clinically healthy

peri-implant tissues.<sup>4,21</sup> Occlusal overload is therefore considered a potential risk factor for peri-implantitis in the presence of plaque and inflammation.<sup>4,21</sup> Given the potential biological and mechanical complications associated with occlusal overload, it is essential to recognize the risk factors that predispose implants to excessive loading and to implement strategies that help control or minimize these forces.

### Risk Factors Associated with Occlusal Overload

Several biomechanical and prosthetic factors can predispose implants to overload and compromise long-term success; they include the following:

#### Parafunctional Habits

Parafunctional habits (such as bruxism and clenching) are strongly associated with increased prosthetic and biologic complications in implant-supported restorations.<sup>4</sup> The magnitude of occlusal forces may vary according to the site and the physical characteristics of these patients, ranging from 100-250 N in the anterior region to 300-800 N in the posterior region.<sup>4</sup> In some patients, parafunctional activity may generate forces exceeding 800 N in the molar area.<sup>4,22</sup>

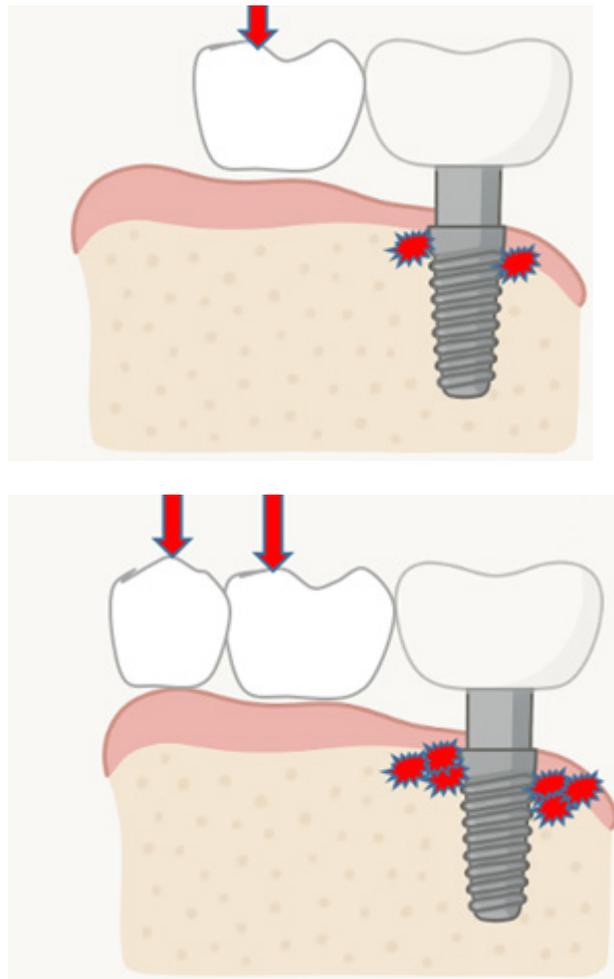
Patients with parafunctional habits not only exhibit greater occlusal loads but also increased contact frequency and duration.<sup>11,23,24</sup> The absence of periodontal ligament-mediated proprioception may further exacerbate parafunctional loading in patients with implant-supported restorations.<sup>11</sup> Many studies have linked bruxism with peri-implant marginal bone loss, implant fracture, and eventual implant failure.<sup>4,11,25,26</sup>

#### Cantilevers

Cantilevers are commonly linked to the generation of non-axial/lateral forces, subjecting the closest supporting implants to bending movements.<sup>4,11,27</sup> They are therefore associated with biomechanical complications

such as screw loosening, screw and framework fractures, prosthetic failure, and peri-implant bone loss.<sup>28</sup>

An increase in the length of the cantilever exponentially increases the stresses on the supporting implant-bone interface (Figure 6).<sup>4</sup> A maximum cantilever length of 15 mm in the mandible and 12 mm in the maxilla has been suggested for a full arch implant-supported fixed prosthesis; however, more conservative recommendations advocate limiting distal cantilevers to 7-8 mm to minimize complications.<sup>4,9,28</sup>



**Figure. 6 Increase in the length of the cantilever exponentially increases stresses at the bone-implant interface.**

*Image Source: AI-generated image*

## Poor Bone Quality

Bone quality is a critical factor affecting implant stability and success. Poor bone quality (e.g., Type IV) coupled with occlusal overload presents an increased risk of biomechanical complications and implant failure.<sup>4,5,29</sup>

## Temporomandibular Disorders

Existing TMJ dysfunctions/disorders may influence occlusal harmony and should be resolved prior to the fabrication of the definitive restorations.<sup>30</sup>

## Poor Patient Compliance

Long-term success of implant restorations depends on the patient's adherence to maintenance protocols, including oral hygiene practices and regular professional follow-up.<sup>31</sup>

## Other Contributing Factors

Additional risk factors include an insufficient number of implants,<sup>4</sup> incorrect distribution of implants, narrow-diameter and/or short/ultrashort implants, ridge deficiencies, improper implant design (decreased thread height, increased thread width),<sup>14</sup> suboptimal passive fit of the prosthetic framework,<sup>14</sup> improper prosthetic design, undesirable distribution of occlusal contacts, premature contacts, steep cuspal inclines, wide occlusal tables, improper loading time, and non-axial loading.<sup>4,9,32</sup>

## Risk Factors Associated with Occlusal Overload

Misch and Bidez introduced the Implant-protected occlusion in the 1990s to limit occlusal overload.<sup>33</sup> This concept emphasizes that, unlike natural teeth, implants are unable to tolerate excessive occlusal forces; therefore, the occlusion must be carefully designed to protect implants from occlusal overload.<sup>33</sup> The principal considerations for reducing occlusal overload are described below:<sup>5,6,33</sup>

### 1. Implant Orientation and Position

Alveolar bone is better adapted to resist

compressive stresses (from axially directed forces) than shear stresses.<sup>14</sup> Lateral or oblique forces create bending moments that generate harmful shear stresses at the implant-bone interface.<sup>14</sup> The greater the deviation of the load from the implant's long axis, the greater the shear stresses, which can lead to bone loss and eventual implant failure.<sup>14</sup> To achieve favorable loading, implants should be placed perpendicular to the occlusal plane, and angled implants or abutments should be avoided unless dictated by anatomic, prosthetic or esthetic requirements.<sup>14</sup> Implant positioning must also be optimized in all three dimensions to minimize offset loading. Planning a cross-bite occlusion for palatally placed posterior implants can help minimize buccal cantilevers and promote axial loading.<sup>5</sup>

### 2. Increasing Surface Area for Load Distribution

Excessive stresses should be managed by using wide-diameter implants, increasing implant length, number, and/or splinting multiple implants.<sup>9</sup> In the maxilla, additional implants can improve force distribution through tripodism (Figure 7).<sup>5</sup> These strategies help increase the surface area for stress distribution, thereby reducing the stresses transferred to the bone.



**Figure. 7 Additional implants in the maxilla improve load distribution.**

### 3. Loading Protocols

Immediate loading should be avoided in regions with compromised bone quality and/or increased occlusal stresses.<sup>5</sup> In such situations, delayed loading or progressive

loading protocols are recommended.<sup>5</sup> Misch et al. proposed the concept of progressive bone loading for implants placed in areas of compromised bone quality.<sup>34</sup> As per this concept, the occlusal forces are gradually increased over six months to promote bone adaptation at the implant interface.<sup>34</sup> Appleton et al. reported that progressively loaded implants exhibited enhanced bone density and reduced crestal bone loss, indicating that extended healing times and carefully staged loading protocols are especially advantageous in areas of compromised bone quality.<sup>35</sup>

### 4. Occlusal Morphology

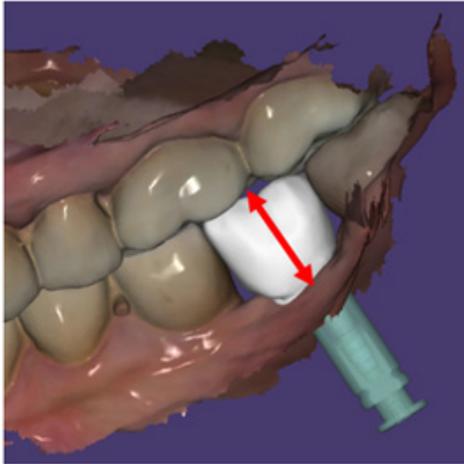
**Cusp Angulation and Fossa Design:** Cusp inclination significantly influences torque generation; with every 10° increase in cusp angle, torque rises by approximately 30%.<sup>6,36</sup> To facilitate axial loading, occlusal contacts on implant crowns should occur on flat surfaces oriented perpendicular to the implant body.<sup>5,6,15</sup> This may be achieved by widening the central fossa (by 2-3mm) and reducing the cuspal inclines (Figure 8) of the implant crown.<sup>5,6,15</sup> In some cases, recontouring of the opposing cusp may be required so that it occludes in the central fossa above the implant body.<sup>6,15</sup>



**Figure. 8 Implant crown (replacing tooth #18) designed with reduced cuspal inclines**

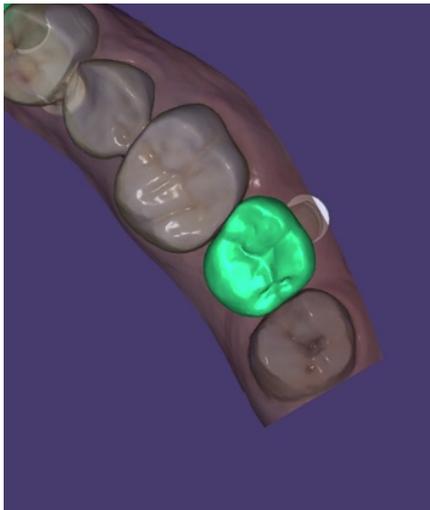
- **Crown Height:** Excessive crown height (Figure 9) acts as a vertical cantilever, magnifying stresses at the bone-implant interface.<sup>5,15</sup> The optimal crown-to-implant

ratio should be maintained.<sup>15</sup> Any discrepancy should be identified at the treatment planning stage, and surgical augmentation should be considered to avoid creating a vertical cantilever.<sup>15</sup> It is also essential to ensure that there is adequate restorative space available for the fabrication of the implant restoration.



**Figure. 9 Excessive crown height**

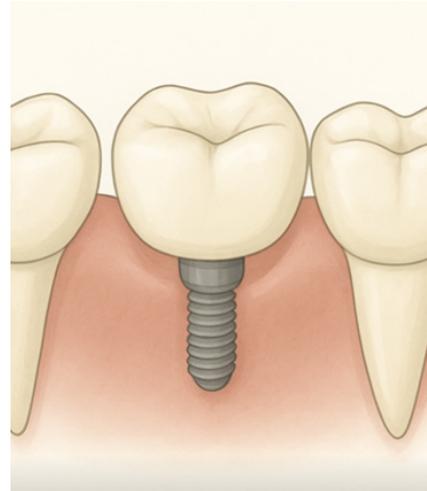
- **Width of the occlusal table:** The width of the occlusal table should be reduced to avoid lateral loading, promote axial force transmission, and limit the chances of restorative material fracture (Figure 10).<sup>5,15</sup>



**Figure. 10 Implant crown replacing tooth #15 planned with a narrow occlusal table.**

- **Occlusal Contact Position:** Primary occlusal contacts should be localized within the central fossa and lie within the implant

diameter (Figure 11).<sup>5</sup> Secondary contacts should be restricted to 1 mm of the implant periphery.<sup>5</sup> Occlusal contacts on the marginal ridge must be eliminated, as they create bending movements.<sup>5</sup>



**Figure. 11 Primary occlusal contacts (blue) localized within the central fossa of the implant crown.**

*Image Source: AI-generated image*

- **Crown Contours:** Due to ridge resorption, implants are generally positioned at the center of the resorbed ridge, usually beneath the central fossa or the lingual cusp of the missing natural tooth.<sup>5,6,15</sup> Additionally, the overall size of the implant body is typically smaller than that of a natural tooth root/roots.<sup>5,6,15</sup> Reproducing the full contour of the original tooth may result in a buccal cantilever, creating an offset load that generates compressive, tensile, and shear stresses at the crestal bone around the implant. It is critical to carefully establish the contours and the occlusal contact positions of the implant restoration to minimize these unfavorable stresses.<sup>5,6</sup>
- **Curves of Spee and Wilson:** It is important to design the occlusal form of the implant restorations in harmony with the existing curves of Spee and Wilson in the natural dentition. These curves play a key role in facilitating protrusive and lateral excursions while minimizing posterior interferences.<sup>37</sup> It is therefore critical to replicate these curves in the occlusal design of the implant prostheses. The occlusal design must not only consider the static intercuspation

but also dynamic mandibular function, to ensure smooth mandibular movements without interferences.<sup>37</sup>

## 5. Cantilever Management

Cantilevers act as force magnifiers and should be eliminated from the prosthetic design whenever possible.<sup>4,6</sup> When their use is inevitable, their length and width must be kept to a minimum, and additional supporting implants should be planned to offset the increased functional load.<sup>4,6</sup> The stresses associated with the cantilevers may be managed through strategies such as increasing the number of implants, optimizing their anteroposterior spread, and splinting them.<sup>4,6</sup> Additionally, use of protective occlusal schemes, including light centric contacts, elimination of contacts in excursions, and avoidance of heavy functional loading on cantilevers, helps with proper stress distribution.<sup>4</sup>

## 6. Restorative Material Selection and Management of Parafunctional Habits

Parafunctional habits such as bruxism and clenching exacerbate occlusal forces, resulting in both biological and mechanical complications.<sup>5,6</sup> High-strength restorative materials, protective occlusal splints, and occlusal designs that minimize lateral contacts are indicated for patients with parafunctional habits.<sup>4,6</sup>

## 7. Establishing Proper Occlusal Contacts

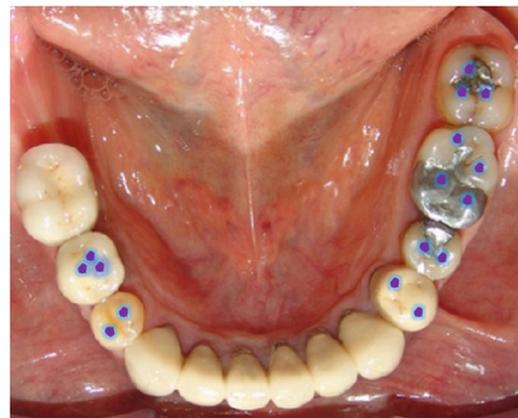
The difference in vertical movement between natural teeth and implants may result in premature occlusal contacts on implant restorations.<sup>5,6</sup> Such prematurities must be carefully eliminated, as they concentrate excessive forces on implants (and the crestal bone) and increase the risk of both biological and prosthetic complications.<sup>5,6</sup> In cases involving both natural teeth and implant-supported restorations, the occlusion must be adjusted to ensure a graded distribution of forces under different functional loads. Articulating paper (thickness less than 25  $\mu\text{m}$ ) and/or Shimstock may be used for the same.<sup>5,6,15</sup> Under light tapping forces, the

implant prosthesis should make only slight contact, while the adjacent natural teeth should display more pronounced initial contacts (Figure 12).<sup>5,6,15</sup> After occlusal equilibration under light force is achieved, heavier occlusal forces are applied, during which the implant crown and adjacent teeth should exhibit contacts of similar intensity (Figure 13), thereby permitting uniform load distribution.<sup>5,6,15</sup>



**Figure. 12 Under light tapping forces, the implant crown replacing tooth # 30 makes light contact, while the adjacent natural teeth display more pronounced initial contacts.**

*Image courtesy: Hatami M; CC-BY-3.0*



**Figure. 13 Under heavier biting forces, the implant crown and adjacent teeth exhibit contacts of similar intensity**

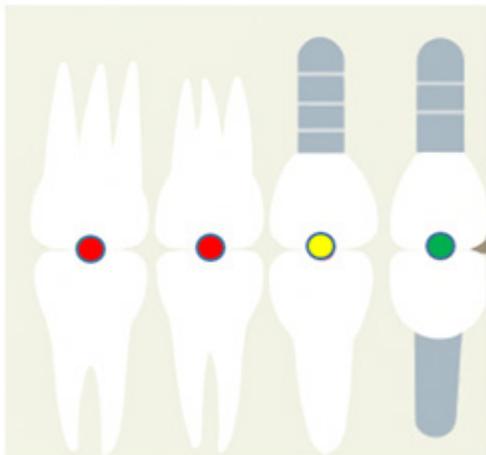
*Image courtesy: Hatami M; CC-BY-3.*

Shimstock testing confirms true occlusal stability. The resistance felt on Shim stock withdrawal in maximum intercuspal position (MIP) confirms true contact (Figure 14), whereas no resistance indicates open contact. When implants oppose natural teeth, the shimstock

should exhibit light resistance under light tapping forces and firm retention during clenching; When an implant opposes other implant restoration, the shimstock should exhibit very light resistance under light tapping forces, with holding resistance during clenching at a slightly reduced level compared to natural dentition (Figure 15). Light resistance is better than no resistance, as no resistance indicates a lack of occlusal contact, which may lead to occlusal instability. However, in complete-arch implant-supported prostheses involving one or both arches, no distinction between light and heavy force contacts is required.



**Figure. 14** The resistance felt on Shimstock withdrawal in MIP confirms true contact.



**Figure. 15** Under light tapping forces, the Shimstock should hold with resistance between the molar teeth (red dots), pull through with light resistance between the upper second premolar implant crown and the lower second premolar tooth (yellow dot), and pull through easily

between the opposing implant crowns (green dot).

*Image Source: AI-generated image*

## Occlusal Schemes in Implant Restorations

The key principles of implant occlusion include bilateral stability in centric occlusion, evenly distributed occlusal contacts and force, a broad freedom in centric, mutually protected occlusion whenever feasible and smooth lateral excursions without working or non-working interferences.<sup>5,9</sup> In addition, the occlusal scheme for implant restorations should be customized and designed in accordance with the opposing dentition or prosthesis, with the primary objective of maintaining occlusal balance and ensuring harmony with existing functional relationships.<sup>5,6</sup>

### 1. Recommended occlusal schemes for single or partial implant restorations

#### *Implant restorations opposing natural dentition*

When an implant restoration opposes natural dentition, the occlusion should be reconstructed in accordance with the patient's preexisting occlusal scheme; when the patient has group function, the implant restoration should be restored to conform to group function, whereas in patients with canine-guided occlusion, it should function as part of the established canine guidance. Working and non-working contacts should be avoided on the implant restoration.<sup>5,9</sup>

When the patient lacks proper occlusion due to several missing teeth, and an implant prosthesis replaces multiple or the majority of posterior teeth in an arch, a mutually protected occlusal scheme (Figure 16) should be planned.<sup>8</sup> The anterior teeth can be adjusted to establish proper anterior guidance, thereby preventing posterior interferences during excursions.<sup>5,8</sup>

When the anterior teeth are being replaced with a fixed implant prosthesis, no contacts (or

very light contacts) should occur in the maximum intercuspal position, and the anterior guidance should be kept shallow, since a steeper incisal path may increase the forces transmitted to the implants.<sup>38</sup> When replacing a canine with an implant restoration, a group function occlusal scheme is recommended to minimize excessive lateral stresses on the implant during mandibular excursions (Figure 17).

#### *Implant Restoration Opposing Fixed Implant Restorations*

When an implant restoration opposes a fixed implant restoration, a mutually protected occlusion is recommended, whenever possible.<sup>8</sup> The occlusion should be designed to achieve light, evenly distributed centric contacts.<sup>8</sup> Excursive contacts should be avoided; however, if present, they must be carefully controlled to avoid harmful lateral loading.<sup>8</sup>

#### *Implant Restoration Opposing a Removable Prosthesis*

All treatment planning decisions for implant-supported restorations should be based on occlusal and prosthetic strategies to protect the weaker arch.<sup>38</sup> Accordingly, the occlusal scheme should be adjusted to accommodate the arch rehabilitated with a complete removable denture/implant overdenture, as it is the weaker arch in the stomatognathic system.<sup>38</sup>

When an implant restoration opposes a removable/removable implant prosthesis, a bilateral balanced occlusal scheme is recommended.<sup>5,32</sup> Bilateral balanced contacts in centric occlusion and during excursive movements are critical for maintaining the stability and retention of removable prostheses.<sup>39</sup> The balanced occlusion may be anatomic balanced or lingualized balanced, depending on clinical factors and the prosthetic design.<sup>39,40</sup>

## **2. Recommended Occlusal Schemes for Full Arch Implant Restorations**

When full-arch fixed prostheses oppose natural dentition or other fixed implant-supported prostheses, a mutually protected occlusal scheme is indicated.<sup>4,5</sup> However, when

canine guidance cannot be achieved due to factors such as overjet, occlusal plane discrepancies, or wear patterns, group function occlusion may be utilized.<sup>4,5</sup> In protrusive movements, the anterior guidance should be distributed over all anterior teeth, including canines, with flat paths and minimal vertical overlap.<sup>4</sup> Lateral excursions should be guided either by canines or through group function, using flat paths to limit occlusal stress.<sup>4</sup> Posterior cantilevers, when present, should be adjusted to have 100 µm clearance in the maximum intercuspal position and should not contact during working and non-working movements.<sup>4,5</sup>

When a full-arch fixed implant prosthesis opposes a complete denture or an overdenture, a bilateral balanced occlusion (Figure 18) is recommended to minimize tipping forces and enhance denture stability.<sup>5</sup> In cases of severe ridge resorption, a monoplane occlusion may be planned.<sup>5</sup>



**Figure. 16** Implant crowns replacing teeth #14 and #15 restored with a mutually protected occlusal scheme.



**Figure. 17** Group function occlusion established for implant restoration replacing tooth #6



**Figure. 18 (A)**



**Figure. 18 (B)**



**Figure. 18 (C)**

**Figure. 18(A) Mandibular full arch fixed implant prosthesis opposing maxillary implant overdenture restored with a (B,C) bilateral balanced occlusion**

## Occlusion-Driven Strategies for Implant Placement and Restoration

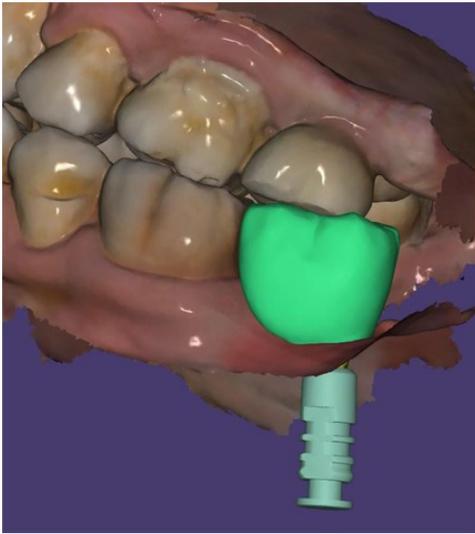
In the past, implant planning was dictated primarily by available bone volume and density. However, over the last two decades,

studies have emphasized the importance of prosthetically driven implant planning for achieving a successful outcome.<sup>41,42</sup> The current evidence stresses that prosthetic considerations alone are insufficient; it is equally important to understand the occlusal considerations, such as the direction, magnitude, and distribution of the occlusal forces and the presence of occlusal risk factors such as parafunctional habits or cantilevers, as they can significantly affect implant longevity and success.<sup>33,43</sup> Therefore, implant planning must integrate anatomic, prosthetic, and biomechanical principles to ensure long-term stability of implant-supported restorations. The following key considerations outline how occlusion-driven principles can be incorporated into implant planning and prosthesis fabrication:

### 1. Diagnosis and Treatment Planning

During the diagnosis and treatment planning stage, the hard and soft tissues, the available restorative space, the most optimal implant position in relation to the proposed final prosthetic tooth position, and all the occlusal risk factors (parafunctional habits, cantilevers, poor bone quality, temporomandibular joint (TMJ) disorders, and poor patient compliance)<sup>25-31</sup> should be thoroughly assessed as they may affect treatment outcomes.<sup>44</sup>

The diameter, length, number, antero-posterior spread, axial inclination, and the location of the implant must be carefully planned, as each factor affects load distribution and long-term outcomes.<sup>45</sup> The position of the implant should be optimized in all three dimensions. Placing the implant apically may create unfavorable vertical cantilevers, while buccolingual or mesiodistal mispositioning (Figure 19) can result in lateral cantilevers and uneven load transfer. Comprehensive planning is critical for establishing a stable and biomechanically favorable occlusion.



**Figure 19. Suboptimal implant positioning in the vertical and mesiodistal planes**

## 2. Establishing Proper Occlusal Vertical Dimension (OVD)

Establishment of proper OVD is critical for the most efficient functioning of the masticatory muscles, stability of the temporomandibular joints, and achieving optimal patient comfort.<sup>46</sup> Special care is required in patients undergoing extensive/full-mouth rehabilitation, where the OVD needs to be re-established for the patient.<sup>47</sup> The proposed new OVD may be tested with an interim restoration allowing the masticatory muscles to adapt, the temporomandibular joint to stabilize, and occlusal relationships to be tested before definitive implant placement.<sup>48</sup> Improper OVD may lead to deleterious effects, including muscular dysfunction, joint trauma, and compromised prosthetic outcomes.<sup>49</sup> Various techniques may be utilized for determining the OVD, such as Niswonger’s method, phonetic method, swallowing method, or other clinician-preferred techniques.<sup>50</sup>

## 3. Recording a Predictable and Repeatable Centric Relation (CR) Position

Maximum intercuspal position (MIP) is a stable and clinically reproducible jaw position that is physiologically acceptable and comfortable for most patients.<sup>51</sup> However, patients who have lost posterior support (Figure 20) and no longer exhibit a stable and reproducible MIP typically require the establishment of a new condyle-

fossa relationship.<sup>51</sup> In these cases, determining an appropriate condylar position is both necessary and integral to achieving successful outcomes.<sup>51</sup> CR is the preferred treatment position in these patients as it represents a physiologic, reproducible, and repeatable mandibular position<sup>51</sup> and is crucial for achieving long-term functional stability.<sup>52</sup>

CR may be obtained through various techniques, including the leaf gauge technique (Figure 21) and Lucia jig (when anterior teeth are present), gothic arch tracing, bimanual manipulation, or chin-point guidance.<sup>53</sup>



**Figure 20. Absence of posterior occlusal support**



**Figure 21. Leaf gauge used for guiding the mandible in the centric relation (CR) position**

## 4. Use of Interim Prostheses to Evaluate and Refine the Restoration Design and Occlusion

Accurate impressions or digital scans, precise interocclusal records, and a properly executed digital or analog wax-up (Figures 22 & 23) are essential for fabricating a high-quality provisional implant restoration. The interim implant restoration should be designed to promote controlled, evenly distributed

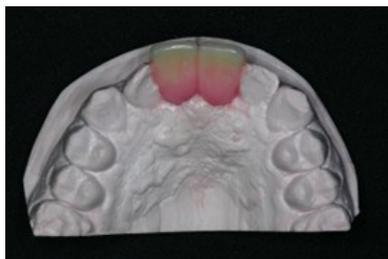
contacts and axial loading, in line with the established principles for minimizing occlusal overload.<sup>4-6,33,36,37</sup> Additionally, broad interproximal contact areas (Figure 24) should be established between natural teeth and implant restorations to promote long-term occlusal stability.



**Figure. 22 Digital Wax-up**



**Figure 23 (A)**

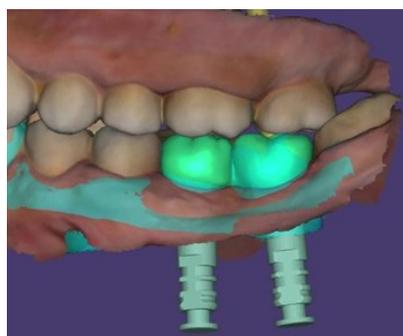


**Figure 23 (B)**



**Figure 23 (C)**

**Figure. 23 Analog wax-up for fabricating a provisional restoration (A,B) #8 and #9, (C) #8, #9, #22-26.**



**Figure. 24 Broad interproximal contact area planned between the natural tooth and the implant restoration**

Interim restorations function as a “trial prosthesis”, permitting the practitioners to test and refine the planned occlusion before fabricating the definitive restoration.<sup>54</sup> Frequent prosthesis fracture, excessive wear, or instability of interim restorations are signs indicative of excessive occlusal forces or occlusal interferences.<sup>52</sup> During this stage, it is critical to adjust the premature contacts, eliminate the interferences, and refine the occlusal design to achieve a stable and harmonious occlusion. A provisional prosthesis enables the patient to develop a functionally generated path that can be accurately transferred to the final restoration. It also enhances patient comfort, improves function, and reduces the risk of complications in the definitive prosthesis.<sup>52</sup> In addition, it facilitates progressive loading, which promotes favorable force distribution, supports soft tissue conditioning, and contributes to predictable long-term outcomes.<sup>55</sup>

## 5. Restorative Material Selection

Restorative material selection should not only be based on the biomechanical properties of the material, but also on the aesthetic and functional needs of the patient, as well as the characteristics of the opposing arch.<sup>56</sup> The literature on the influence of the restorative material on the stresses transmitted to the implant and the peri-implant bone remains inconclusive.<sup>57</sup>

Additionally, it is important to choose a material with low wear values to maintain

occlusal stability over time.<sup>58</sup> Materials like PMMA have high wear values (~100 µm), whereas zirconia exhibits very low wear values.<sup>4</sup> Materials like PMMA should therefore be used as interim restorations.<sup>4</sup> For definitive, long-term restorations, high-strength materials that incorporate titanium frameworks with zirconia may be the preferred choice.<sup>4</sup> However, zirconia has its own limitations. It requires adequate bulk for strength, proper polishing after adjustments, and re-sintering after excessive adjustments.<sup>59</sup>

## 6. Implementing the Planned Design in the Definitive Prosthesis

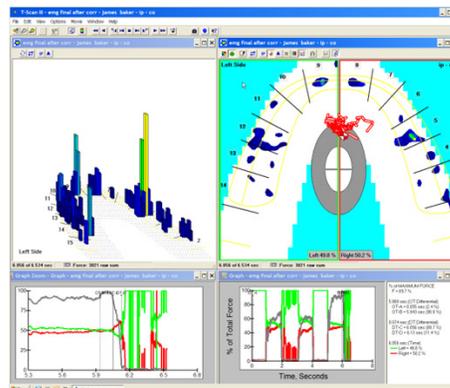
The restoration design and occlusion established with the interim prosthesis must be carefully implemented in the definitive restoration<sup>60</sup> through accurate implant-level or abutment-level impressions or digital scans, precise interocclusal records, and digital scans/impressions of the provisional restoration.<sup>60</sup> Following the definitive prosthesis fabrication, further refinement may be necessary to ensure harmonious occlusal contacts and to eliminate prematurities or interferences that could compromise long-term success.<sup>60</sup> Such adjustments may be performed extraorally through a clinical remount<sup>61</sup> (Figure 25) or intraorally using articulating paper, shimstock[A1] [A2], or digital occlusal analysis tools such as the T-scan (Figures 26 & 27).<sup>62</sup>



**Figure. 25 Clinical remount procedure performed for occlusal refinement.**



**Figure. 26 T-scan bite fork with sensor placed between the maxillary and mandibular teeth.**



**Figure. 27 T-Scan measures and displays the timing and intensity (force) of occlusal contacts.**

## 7. Maintenance and Recall

The success of implant-supported restorations is associated with appropriately established maintenance and follow-up regimens.<sup>63</sup> Patients must be educated on proper oral hygiene practices to maintain the health of the implant and the surrounding tissues.<sup>64</sup> In addition, they should be instructed to monitor for complications such as changes in the bite,<sup>65</sup> mobility or fracture of the prosthesis.

Due to the differences in the biomechanical and physiological features of natural teeth and implants, progressive alterations in an established occlusion will occur over the course of time.<sup>5,6</sup> Studies have reported that implant restorations may develop occlusal prematurities<sup>5,6</sup> and loss of interproximal contacts with time.<sup>65,66</sup> Thus, restorations that initially present with proper occlusal and interproximal contacts may later exhibit premature contacts and/or little to no interproximal contact.<sup>5,6,55,56</sup>

Periodic recall appointments, ideally every six months or more frequently in high-risk patients, are essential.<sup>67</sup> Recall appointments allow early identification of premature contacts and occlusal interferences, permitting timely correction and limiting/avoiding excessive stresses on the implants.<sup>65</sup> These measures not only preserve peri-implant tissues but also improve the longevity and biomechanical stability of the restoration.

## Summary

Occlusal forces over implant restorations should be evenly distributed to reduce the risk of implant overloading. Because natural teeth and implants respond differently to occlusal load, graded occlusal contacts are advisable when both are present. The goal is for implant restorations to achieve full contact only during firm intercuspation. At the same time, it is essential to establish proper functional contacts, as implant restorations in infraocclusion (even in firm intercuspation) are not acceptable.

The occlusal forces should be directed along the long axis of the implant, while lateral and oblique forces should be eliminated, as these generate harmful shear stresses at the bone-implant interface. Occlusal splints should be fabricated for patients with parafunctional habits or who are at risk of restoration complications due to occlusal overload.<sup>65</sup>

Long-term success with implant restorations requires a structured follow-up and maintenance program. Recall visits should include evaluation of occlusal contacts, prosthesis stability, and peri-implant health, with adjustments performed as needed to accommodate progressive occlusal changes over time.

## Course Test Preview

To receive Continuing Education credit for this course, you must complete the online test. Please go to: [www.dentalcare.com/en-us/ce-courses/ce669/test](http://www.dentalcare.com/en-us/ce-courses/ce669/test)

- 1. What is the primary factor responsible for the difference in functional adaptability of implants compared to natural teeth?**
  - A. Absence of cementum
  - B. Absence of dentin
  - C. Absence of periodontal ligament
  - D. Absence of pulp and nerves
  
- 2. Which is not a function of the periodontal ligament?**
  - A. Cushioning
  - B. Functional adaptability
  - C. Osseoperception
  - D. Proprioception
  - E. Shock absorption
  
- 3. What is the elastic modulus of dentin compared to bone?**
  - A. 5 to 10 times less than bone
  - B. 5 to 10 times more than bone
  - C. Double that of bone
  - D. Same as bone
  
- 4. What is the occlusal perception threshold between an implant and a natural tooth?**
  - A. 20  $\mu\text{m}$
  - B. 48  $\mu\text{m}$
  - C. 64  $\mu\text{m}$
  - D. 108  $\mu\text{m}$
  
- 5. When natural teeth are subjected to trauma, they exhibit early signs such as fremitus, hyperemia, and periodontal ligament widening. Implants, on the other hand, display only pain as an early warning sign.**
  - A. Both statements are correct.
  - B. Both statements are false.
  - C. The first statement is correct, the second is false.
  - D. The second statement is correct, the first is false.
  
- 6. Under functional loading, a natural tooth moves approximately how many micrometers in the axial and horizontal directions, respectively?**
  - A. 3–5  $\mu\text{m}$  axially, 10–50  $\mu\text{m}$  horizontally
  - B. 10–50  $\mu\text{m}$  axially, 3–5  $\mu\text{m}$  horizontally
  - C. 25–100  $\mu\text{m}$  axially, 56–150  $\mu\text{m}$  horizontally
  - D. 56–150  $\mu\text{m}$  axially, 25–100  $\mu\text{m}$  horizontally
  
- 7. The fulcrum of lateral forces in natural teeth is located in which region?**
  - A. Apical third of the root
  - B. Cervical third of the crown
  - C. Coronal third of the root
  - D. Middle third of the root

**8. Under light tapping forces, the implant prosthesis should make only slight contact, while the adjacent natural teeth should display more pronounced initial contacts. Under heavier occlusal forces, the implant crown and adjacent teeth should exhibit contacts of similar intensity.**

- A. Both statements are correct.
- B. Both statements are false.
- C. The first statement is correct, the second is false.
- D. The second statement is correct, the first is false.

**9. Which is not recommended to decrease the changes of occlusal overload?**

- A. Decrease cuspal inclines
- B. Eliminate cantilevers
- C. Increase the width of the occlusal table
- D. Widen the central fossa

**10. For an implant restoration opposing an implant overdenture, which occlusal scheme is most likely recommended?**

- A. Balanced occlusion
- B. Canine-guided occlusion
- C. Group function
- D. Mutually protected occlusion

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### **Additional Resources**

- No Additional Resources Available

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