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SERÜVEN
YAYINEVİ

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Chapter 1

MONOLITHIC ZIRCONIA

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1. Introduction and Objective

Prosthetic restorations, employed to replace lost dental tissues due to trauma, deep caries, and aesthetic concerns, have become a crucial aspect of modern dentistry. Although metal-supported porcelain restorations have been widely utilized for many years, their disadvantages, such as corrosion, allergic reactions, and aesthetic incompatibilities, have necessitated the development of alternative materials (1).

The drawbacks of metal-ceramic restorations and increasing aesthetic demands have paved the way for the use of all-ceramic systems as viable alternatives. The introduction of aluminous core porcelain materials by John McLean in 1965 marked the beginning of this transition, which has since evolved with enhancements in aesthetic and durability properties. The examination of the aesthetic and mechanical characteristics of all-ceramic materials highlights the necessity for solutions that balance both factors effectively.

Feldspathic porcelains and glass ceramics exhibit excellent optical properties; however, their mechanical strength is insufficient for posterior restorations. Zirconium oxide ceramics, developed in the 1990s, have become suitable for posterior restorations, where high masticatory forces are exerted. Nevertheless, their opaque structure necessitates veneering for aesthetic purposes, and chipping of these veneering materials has been reported as a significant issue (2).

2.1 Classification of All-Ceramic Systems in Dentistry

Gracis et al. classified dental ceramics into three main groups:

2.1.1 Glass Matrix Ceramics

These ceramics contain a glass phase and are composed of inorganic, non-metallic materials. They are preferred due to their superior aesthetic properties and translucency and are categorized into three subgroups:

- **Naturally Feldspathic Ceramics:** Traditional ceramics composed of feldspar, quartz, and kaolin. Feldspathic ceramics are notable for their high translucency and are primarily used in the anterior region (3).
- **Synthetic Ceramics:** Developed to reduce dependence on natural raw materials while improving aesthetic and mechanical properties.
    - o **Leucite-Reinforced Ceramics:** Used to adjust the coefficient of thermal expansion and enhance durability.

- **Lithium Disilicate Ceramics:** Provide high strength and aesthetic appeal.
- **Fluorapatite Ceramics:** Feature improved translucency and aesthetic properties.

2.1.2 Glass-Infiltrated Ceramics

These ceramics contain alumina, aluminum-magnesium, or aluminum-zirconia compositions and are reinforced with glass infiltration to enhance mechanical strength. However, their usage has been declining (4).

2.1.3 Polycrystalline Ceramics

These ceramics lack a glass phase, making chemical surface roughening difficult. Due to their high strength, they are predominantly used in posterior restorations.

- **Alumina:** Contains high-purity aluminum oxide.
- **Stabilized Zirconia:** Its tetragonal phase is stabilized to enhance fracture resistance.

2.1.4 Resin-Matrix Ceramics

These materials consist of an organic matrix reinforced with high concentrations of ceramic particles.

- **Resin Nano-Ceramics:** Offer ease of processing and flexibility.
- **Resin-Matrix Glass Ceramics:** A hybrid structure providing both aesthetic and mechanical durability.
- **Resin-Matrix Zirconia-Silica Ceramics:** Comprise a combination of inorganic structures and polymer matrices (5).

2.2 Structure of Zirconia

Zirconium (Zr) is a chemical element whose name originates from the word "Zargon," meaning "gold-colored." It does not occur freely in nature; its most important compound is zirconium oxide (ZrO_2, zirconia). Zirconia exists in the monoclinic phase up to 1170°C, transforming into a tetragonal phase at higher temperatures and eventually into a cubic phase. During cooling after sintering, the tetragonal-to-monoclinic phase transformation occurs, positively influencing mechanical strength. However, uncontrolled volume expansion during this transformation may lead to fractures (6).

To stabilize zirconia at room temperature, metal oxides such as calcium, magnesium, and yttrium are added to its structure. Since the tetragonal phase is "metastable," it may revert to the monoclinic phase under specific conditions. This transformation is critical in enhancing zirconia's mechanical properties for dental applications. As zirconia lacks a glass matrix, it offers superior long-term stability; however, its mechanical strength may be affected by low-temperature degradation (LTD) (Figure 1).

Zirconia's white color and high mechanical strength provide a significant aesthetic advantage over metal-ceramic restorations. Its flexural strength ranges between 900-1200 MPa, while its fracture toughness is recorded at 9-10 MPa. With an elastic modulus of approximately 200 MPa, zirconia plays a crucial role in posterior restorations, reducing stress on weaker veneering materials and delaying fracture onset (7).

Moreover, zirconia has demonstrated no mutagenic or carcinogenic effects and exhibits lower bacterial plaque accumulation compared to titanium, further highlighting its biocompatibility.

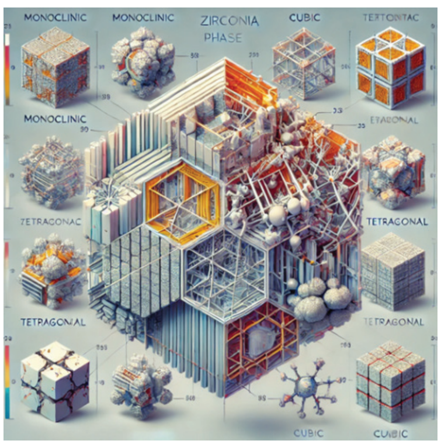

Figure 1: Three-Dimensional Design of Zirconia Phase Transformation

2.4 Historical Development of Zirconia Ceramics in Dentistry

Metal-supported porcelain restorations were long considered the "gold standard" due to their superior mechanical properties, marginal and internal adaptation, and acceptable aesthetic qualities. The foundation for all-ceramic systems was laid in the late 19th century when Charles Land introduced porcelain jacket crowns. However, due to their mechanical limitations, research aimed at improving ceramic properties gained momentum over time (8).

In 1965, John McLean introduced an aluminous core material containing 40-50% glass matrix, marking a crucial step in enhancing mechanical durability. However, due to its opaque appearance, it was used with a feldspathic porcelain veneer. In the early 1990s, Dicor developed pressable glass ceramics containing 34% leucite, offering durability and marginal adaptation similar to glass ceramics. During this period, Ivoclar Vivadent introduced IPS Empress 2, increasing lithium disilicate content to 70%, doubling its fracture resistance, and making it suitable for posterior restorations (9).

The rapid advancements in CAD/CAM technology accelerated the production of monolithic restoration materials and contributed to their popularity. The use of polychromatic zirconia ceramic blocks, which mimic the color transitions between enamel and dentin, became a milestone in meeting aesthetic expectations(10).

Key zirconia materials in historical development include:

- **Partially Stabilized Zirconia (PSZ)**
- **Zirconia-Toughened Alumina (ZTA) and Alumina-Toughened Zirconia (ATZ)**
- **Yttria-Stabilized Tetragonal Zirconia Polycrystal (Y-TZP)**

Y-TZP-based framework systems provide flexural strengths of 900-1200 MPa and offer three times higher fracture resistance. However, their metastable structure requires controlled phase transformations.

2.5. Clinical Applications of Zirconia

With the advancement of CAD/CAM technology in the 1990s, zirconia became widely used in dentistry. Monolithic zirconia is utilized in implant materials, abutments, endodontic posts, and prosthetic restorations.

2.5.1. Implant Material

Zirconia is recognized for its biocompatibility and successful osseointegration as an implant material. However, further research is required to establish its viability as an alternative to titanium implants.

2.5.2. Implant Abutments

Zirconia abutments offer advantages in terms of aesthetics and biocompatibility. Compared to titanium abutments, they result in less plaque accumulation, although they have lower fracture resistance. Proper design and occlusal control are essential for ensuring long-term success.

2.5.3. Endodontic Posts

Zirconia posts are valued for their aesthetic benefits and high mechanical strength. However, they exhibit lower bonding strength and are more challenging to remove compared to metal posts.

2.5.4. Precision Attachment Systems

Zirconia is used in precision attachment systems due to its stability and aesthetic advantages. These systems enhance patient comfort and provide a long-term biocompatible solution.

2.5.5. Inlay and Onlay Restorations

Zirconia is preferred for inlay and onlay restorations because of its durability and aesthetic properties. These restorations are long-lasting and excel in detailed processing capabilities(11).

2.5.6. Zirconia as a Telescopic Primary Structure

Zirconia provides long-term retention and durability in telescopic systems. Compared to gold and metal systems, it offers the advantage of more consistent retention over time (12).

3. Monolithic Zirconia Restorations

The term "monolithic" is derived from the Greek words "mono" (single) and "lithic" (stone), referring to restorations composed of a single material. Initially, zirconia ceramics were used as framework materials covered with feldspathic porcelain due to their inherent opacity. However, the most common issue shortening the lifespan of these restorations was veneer porcelain fractures (13).

Monolithic zirconia restorations, produced using CAD/CAM technology without the need for veneer porcelain, have resolved these challenges. By reducing the alumina content, translucency has been increased, and aesthetic properties have been enhanced. These restorations are characterized by their high flexural strength (1570 MPa), thermal resistance (2600°C), biocompatibility, and low opacity (14).

3.1. Classification of Monolithic Zirconia

1. **Based on Chemical Composition:**

   - **3Y-TZP (3 mol% yttrium oxide):** Notable for its high strength.
   - **4Y-TZP and 5Y-TZP:** Developed for enhanced aesthetics.

2. **Based on Phase Transformation:**

   - **Tetragonal phase monolithic zirconia:** Prevents crack propagation, ensuring high mechanical strength.

3. **Based on Translucency:**

   - Available in low, medium, and high translucency levels.
   - Low translucency is preferred for posterior teeth, while high translucency is used for anterior teeth (15).

4. **Based on Intended Use:**

   - Monolithic zirconia, which does not require porcelain veneering, offers durability for posterior teeth and aesthetics for anterior teeth.

5. **Based on Mechanical Strength:**

   - High-strength monolithic zirconia is resistant to occlusal forces while providing aesthetic solutions.

3.2. Advantages of Monolithic Zirconia Restorations

The advantages of monolithic zirconia restorations can be summarized as follows (16):

- Require less tooth preparation compared to feldspathic porcelain-covered systems, preserving dental tissue.
- Simplified manufacturing steps through CAD/CAM technology, minimizing laboratory procedures.
- Exhibit excellent biocompatibility.
- Preferred in cases with limited interocclusal space due to their high fracture resistance.
- Demonstrate superior mechanical strength compared to other ceramics, with a flexural strength of 900–1200 MPa and a fracture toughness of 6–10 MPa/m1/2.

3.3. Disadvantages of Monolithic Zirconia Restorations

The disadvantages of monolithic zirconia restorations can be summarized as follows (17):

- Due to CAD/CAM production techniques, zirconia blocks, and milling costs, they are more expensive than conventional ceramic restorations.
- Their intraoral adaptation is more challenging and time-consuming compared to traditional porcelain restorations.
- They cannot be repaired once fractured.
- Although their translucency has been improved, they still do not mimic the natural appearance of teeth as effectively as glass ceramics.

3.4. Physical Properties of Monolithic Zirconia Restorations

3.4.1. Fracture Strength, Flexural Resistance, and Elastic Modulus

Kok et al. reported that monolithic zirconia crowns have higher fracture strength than veneered lithium disilicate crowns. Sun et al. demonstrated that monolithic zirconia ceramics exhibit greater load-bearing capacity than lithium disilicate and metal-ceramic restorations. However, it has been noted that as thickness decreases, fracture strength also declines (18).

3.4.2. Hardness

The rigid nature of monolithic zirconia ceramics has raised concerns about their potential to cause wear on opposing teeth. However, abrasive effects depend not only on hardness but also on surface properties. Polishing procedures have been found effective in reducing abrasive effects.

3.4.3. Surface Wear

The surface wear of monolithic zirconia restorations is influenced by factors such as roughness, occlusal forces, and other mechanical properties. Studies indicate that polishing procedures result in less wear compared to glazing applications.

3.4.4. Optical Properties

The optical properties of monolithic zirconia ceramics offer lower translucency compared to natural teeth. Yttria-tetragonal zirconia polycrystals (Y-TZP) are categorized into four generations:

1. **First Generation (3Y-TZP):** Traditional, low-translucency material.
2. **Second Generation (3Y-TZP):** Improved translucency and mechanical properties.
3. **Third Generation (5Y-TZP):** Higher translucency but lower mechanical strength.
4. **Fourth Generation (4Y-TZP):** Balanced in both translucency and strength (19). Examples include Katana STML and IPS e.max ZirCAD Prime.

3.5. Indications for Monolithic Zirconia

Monolithic zirconia is widely used in dentistry due to its extensive range of applications and various advantages:

- **Preparation Advantage:**

Allows for reduced preparation in cases with limited crown height. Even at minimal thicknesses, restorations exhibit high mechanical strength.

- **Aesthetic and Color Options:**

High-strength monolithic zirconia blocks offer varying translucency levels and a wide range of color options, making them suitable for both anterior and posterior restorations. They meet aesthetic demands through manufacturer-provided shade options or laboratory staining techniques (20).

Extensive Applications:

- Fabrication of implant-supported hybrid prostheses and custom abutments
- Inlay and onlay restorations
- All indications involving zirconia-based restorations

Additional Applications:

- Long-span bridge prostheses
- Full-arch bridge prostheses
- Implant-supported prostheses (Figure 2-3)
- Endocrowns
- Cases with limited interocclusal space

The exceptional mechanical strength and biocompatibility of monolithic zirconia enable its reliable use across a wide range of indications in dentistry.

Figure 2: Image of a hybrid prosthesis fabricated with monolithic zirconia

Figure 3: Image of a Toronto framework and suprastructure fabricated with monolithic zirconia

3.6. Contraindications of Monolithic Zirconia

- **Excessively narrow interocclusal space**: When there is insufficient space to achieve the minimum required thickness for zirconia restorations, its use is not recommended.

- **High esthetic demands in the anterior region**: Due to its greater opacity compared to full-ceramic restorations, monolithic zirconia may not be suitable for patients with high translucency expectations.

- **Parafunctional habits**: In cases with severe parafunctional habits such as bruxism, zirconia restorations may be subjected to excessive forces, which can compromise their long-term success.

- **Deep subgingival margins**: Ensuring proper placement and maintaining periodontal health may be challenging in cases with deep subgingival margins (21).

3.7. Clinical Advantages of Monolithic Zirconia Compared to Veneered Zirconia

Monolithic zirconia exhibits high mechanical strength even at reduced thicknesses. Studies have demonstrated that when used at a minimum occlusal thickness of 0.5 mm, monolithic zirconia provides adequate durability under masticatory forces. This characteristic makes it advantageous in cases with reduced interocclusal space or short clinical crowns. Additionally, monolithic zirconia restorations require less preparation compared to metal- or zirconia-supported layered restorations, minimizing the risk of pulpal damage in younger patients. The elimination of bonding failures and enhanced translucency further contribute to improved clinical success.

3.8. Polishing of Monolithic Zirconia

The polishing process is essential to achieve a smooth surface on monolithic zirconia restorations. Polishing reduces the abrasive effects of rough surfaces on antagonist teeth. Clinical polishing procedures are performed using rotary instruments and specialized polishing kits, offering a practical and effective solution.

3.9. Cementation of Zirconia Restorations

The long-term success of zirconia restorations depends on appropriate cementation techniques. Resin-based cements provide superior marginal adaptation and fracture resistance. Compared to conventional cements, resin cements with light-transmitting properties better fulfill esthetic expectations (22).

4. Fabrication of Monolithic Zirconia Using CAD/CAM Technology

CAD/CAM technology plays a crucial role in modern dentistry by enabling the production of monolithic zirconia restorations that combine esthetics, durability, and biocompatibility. The process begins with digital scanning and is completed by fabricating restorations tailored to the patient's oral anatomy.

4.1. Digital Scanning and Design

The patient's dentition is scanned using intraoral scanners or model-based scans, converting the data into a digital model. CAD software is then used to design the restoration, adjusting its dimensions, morphology, and compatibility with adjacent and opposing teeth. The design is customized to match the patient's unique anatomical structure.

4.2. Preparation and Milling of Zirconia Blocks

Once the design is finalized, the CAM process begins. Semi-sintered zirconia blocks are milled using CNC machines. During this process, a shrinkage allowance of approximately 20% is factored in to ensure the final restoration's accurate fit after sintering.

4.3. Sintering

After milling, the zirconia restorations are subjected to sintering at temperatures ranging from 1350°C to 1500°C. This process enhances the density of zirconia grains, significantly improving its mechanical properties. The shrinkage occurring during sintering is accounted for in the design phase.

4.4. Surface Treatments and Polishing

Following sintering, the restorations undergo surface finishing to achieve a smooth and biocompatible surface. Custom staining and glazing are performed according to the patient's esthetic expectations. This step ensures that the final restorations are both durable and visually appealing.

4.5. Clinical Application and Evaluation

The completed restorations are assessed for fit and function in the patient's mouth before final cementation. Due to the superior mechanical properties of monolithic zirconia, it provides long-term success, particularly in posterior restorations. Proper evaluation and careful placement during clinical application are critical to achieving optimal results (Figure 5) (22).

Figure 5: Image depicting the stages of digital scanning, milling, sintering, surface treatments, and clinical application.

5. CONCLUSIONS

Monolithic zirconia has demonstrated favorable outcomes as an esthetic and functional option for implant-supported fixed dental prostheses (FDPs) in dentistry. Clinical reports indicate that monolithic zirconia maintains successful performance for up to four years. It is particularly highlighted as a suitable material for esthetic restorations and posterior prosthetic applications. However, in screw-retained restorations, excessive stress has been reported to pose a risk of crack formation (23).

Monolithic zirconia stands out due to its high fracture resistance and biocompatibility. Studies have shown that it can withstand maximum strength even at a reduced thickness of 0.5 mm, with significantly increased durability in thicker restorat ions. Additionally, polished monolithic zirconia has been found to be less abrasive to opposing dentition compared to glazed zirconia and veneered porcelain. These properties make monolithic zirconia an ideal candidate for posterior restorations, especially in patients with parafunctional habits such as bruxism and teeth clenching.

Nevertheless, further research is needed to investigate the long-term degradation resistance of monolithic zirconia, particularly regarding its resistance to wear and its susceptibility to low-temperature degradation (LTD) in humid environments. Comprehensive clinical studies should be conducted to evaluate these factors, as they directly impact the long-term durability of the material. Additionally, beyond translucency, further studies should focus on other esthetic aspects to optimize the material's application in anterior restorations (24).

In the future, advancements in nanotechnology within dentistry could further enhance the strength and esthetic properties of monolithic zirconia. Particularly, with the continuous progress of computer-aided design and manufacturing (CAD/CAM) technologies, more precise and patient-specific restoration solutions will become available. Monolithic zirconia has established a significant position in dentistry due to its high mechanical strength and esthetic advantages. However, further research is necessary to maximize its long-term benefits and explore additional clinical advantages (25).

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Chapter 2

NON-CARIOUS CERVICAL LESIONS AND RESTORATIVE TREATMENT OPTIONS

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Tooth surface loss or dental wear refers to the irreversible loss of dental hard tissue due to trauma or non-cariogenic factors, and it typically occurs as a result of destructive interactions. Such hard tissue losses can be evaluated as either physiological or pathological. Physiological wear can occur on interproximal tooth surfaces due to adjustments necessary for chewing and proper tooth function or due to friction between adjacent teeth. Pathological wear, on the other hand, refers to the unacceptable loss of dental hard tissue, characterized by abnormal destruction that may require treatment (Bassiouny, 2012; Davies, Gray, & Qualtrough, 2002; Kaidonis, 2008; Van't Spijker et al., 2009).

Non-carious cervical lesions can arise from a variety of different factors. Depending on these factors, lesions can be classified as erosion, attrition, abrasion, or abfraction. Additionally, multifactorial lesions, resulting from the combination of several factors, may also be observed (Lussi, 2006; Lussi, Schlüter, Rakhmatullina, & Ganss, 2011).

ANAMNESIS AND CLINICAL EXAMINATION

- **Personal Information**: Age, gender, and occupational details should be inquired. As age increases, tooth wear may become more pronounced due to the longer duration of exposure to causative factors. In age-related wear, sclerotic dentin forms, which reduces sensitivity, whereas in rapidly progressing wear, sclerotic dentin cannot form, leading to increased sensitivity. The frequency and pattern of wear can vary based on gender. Professionally, individuals involved in swimming may frequently experience erosion.

- **Systemic Diseases and Medical History**: The patient's medical history, including medications, pregnancy, bulimia, anorexia nervosa, reflux, and issues such as heartburn, should be reviewed. Medications that reduce salivary flow rate should be assessed for their potential to increase susceptibility to erosion.

- **Factors in Wear:**

1.Erosive Factors: The patient should be asked to record their diet for five days. This list should include their preferred main meals, desserts, drinks, and the frequency and amount of consumption, with all details noted carefully.

2.Abrasive Factors and Oral Habits: The patient should be asked about the type of toothbrush used, the hardness of the bristles, the frequency and duration of brushing, the type of toothpaste used, and their method of using interproximal brushes and dental floss.

3.Parafunctional Habits: The type, duration, and intensity of these habits should be questioned. For patients with joint pain, the location of the pain and its intensity on a scale from 0 to 10 should be assessed.

4.Sensitivity: Patients should rate their sensitivity to cold and sour foods on a scale from 0 to 10.

- During the clinical examination, the dentist identifies the localization of dental wear (posterior or anterior region), the affected tooth surface (buccal, lingual/palatal, occlusal/incisal), the surface area, the type of dental tissue involved (enamel, dentin), and the wear type (U-shaped or V-shaped). Regular follow-ups and the records taken during these visits are important for determining whether the wear is progressing. Periodontal health should be evaluated alongside radiographs. During the clinical examination, occlusal relationships, bite, and temporomandibular joint disorders should be assessed to gain insight into the occlusal forces. Additionally, information regarding stimulated and unstimulated saliva flow rates and the buffering capacity of saliva should be collected (Chu, Yip, Newsome, Chow, & Smales, 2002; Grippo, Simring, & Schreiner, 2004; A. Lee, He, Lyons, & Swain, 2012)

EROSION

Tooth surface erosion refers to the dissolution of mineralized dental tissue due to the action of non-bacterial acids. Factors that influence the severity of erosion include the amount and temperature of the acidic substance, as well as the duration of its contact with the tooth's hard tissue (Addy & Shellis, 2006). The acids responsible for dental erosion can be intrinsic (refluxed stomach acid) or extrinsic (dietary components such as acidic industrial fumes, soft drinks, pickles, and acidic fruits) (Nunn, 2000; Zero & Lussi, 2000).

Enamel: Enamel exposed to acid loses minerals from a layer extending a few micrometers beneath the surface, a process known as softening, which makes the surface tissue highly susceptible to mechanical wear. Over time, as the softening progresses deeper into the enamel, the most superficial layer dissolves, causing the outer enamel to disappear completely. The pH drop on the tooth surface after consuming an acidic beverage often seems to be short-lived, likely causing only softening. However, repeated intake of erosive drinks can promote some tissue loss through demineralization. Under in vivo conditions, erosion can lead to two types of enamel wear: the mechanical wear of the thin, soft layer (erosive tooth wear) and, in extreme cases, the direct loss of hard tissue through prolonged demineralization (Eisenburger, Hughes, West, Jandt,

& Addy, 2000; Koulourides, 1968; Millward, Shaw, Harrington, & Smith, 1997; Schweizer-Hirt, 1978).

Dentin: When dentin is exposed to acid, the initial effect is dissolution at the junction between peritubular and intertubular dentin. This process leads to the loss of peritubular dentin and the widening of the tubule lumen (Meurman, Drysdale, & Frank, 1991). "Dissolution desensitization" (i.e., the mineral loss that occurs due to acid exposure of dentin) continues as demineralization progresses in the underlying tissue. This process results in a thin layer of demineralized collagen matrix (the protein structure that forms the building block of dental tissue) on the surface. This layer plays a crucial role in the process of dental erosion because it mechanically protects the underlying residual dentin and also influences the chemical reactions between this dentin and the oral environment. Furthermore, it acts as a diffusion barrier that affects the speed and pattern of dentin erosion (Kleter, Damen, Everts, Niehof, & Ten Cate, 1994; Shellis, Barbour, Jones, & Addy, 2010).

Etiological Factors of Erosion

Extrinsic Acid Sources	
Acidic Foods	**Beverages, salad dressings, wines, vinegar**
Acidic Medications	**Iron supplements, Vitamin C, aspirin**
Occupational Acid Exposure	**Professional swimmers, wine tasters, workers in battery, galvanizing, and munitions factories**

Intrinsic Acid Sources:

Intrinsic causes of erosion include anorexia nervosa, bulimia nervosa, pregnancy, endocrine disorders, and gastroesophageal reflux.

Clinical Appearance of Erosion:

- Wear lesions typically have rounded edges.
- Occlusal surfaces flatten, and tooth cusps may collapse.
- In severe cases, the occlusal anatomy may be completely lost.
- Lingual and labial smooth surfaces may flatten, and a solid enamel ring may be present along the gingival margin.

- Depressions (concavities) may appear on the affected tooth surfaces.

- A reduction in the occlusal vertical dimension (OVD) and an increase in the interocclusal space may be observed.

- Restorations, such as amalgam, may remain more prominent than the surrounding tooth surface due to wear.

- Lesions may affect only the enamel or may extend into the dentin.

- Lesions may be localized, affecting only one tooth and/or surface.

- Lesions can also be generalized, distributed symmetrically or asymmetrically (Carvalho et al., 2015).

Clinical Appearance of Erosion on the Buccal Surfaces:

- In the early stages of lesions, an orange peel appearance and fluctuations in the enamel are observed.

- In lesions that progress slowly and regularly, the enamel becomes flat, and a step in the enamel forms at the cervical area. The edges of these lesions are rounded, with a width greater than the depth, and they appear concave.

- In rapidly progressing lesions, the enamel maintains the orange peel appearance, and the amount of wear is significant. The surface of these lesions appears smooth and stain-free.

Clinical Appearance of Erosion on the Lingual/Palatal Surfaces: On the palatal/lingual surfaces of the teeth, the singulum is lost, a concave surface forms, and an enamel step develops.

Clinical Appearance of Erosion on the Occlusal Surfaces: In the posterior region, wear is observed on the cusps (patognomonic wear). Additionally, the loss of occlusal enamel morphology is also noted.

Protective Approaches in Erosion

1. Limit the consumption of acidic foods and beverages.

2. Acidic foods should not be held in the mouth, and contact should be minimized as much as possible (e.g., using a straw).

3. Do not brush teeth immediately after consuming acidic foods; wait at least 20-30 minutes.

4. Oral hygiene education should be provided, soft toothbrushes should be used, and abrasive-containing toothpaste and mouthwashes should be avoided.

5. Collaboration with medical professionals is essential for investigating and managing underlying medical issues:

o **Gastroenterologist**: A 24-hour pH monitor can be placed in the esophagus to assess the frequency and severity of reflux before medical and/or surgical treatment.

o **Psychiatrist**: Can offer counseling to patients with eating disorders to correct any misperceptions about their self-image.

o **Dentist**: Can replace medications that cause xerostomia with suitable alternatives.

Evaluating family and social history can help identify any unusual stress, such as bruxism, dietary changes, or regurgitation. A diet form is useful for recording the frequency and amount of citrus fruit and carbonated beverage consumption (DePaola, 2000; Donachie & Walls, 1996).

ABRASION

Abrasion is pathological wear caused by friction between the tooth and an external source (Addy & Shellis, 2006). The distribution of lesions can help the dentist accurately identify risk factors. For example, lesions localized on one side in the second quadrant may be associated with an improper brushing technique in a right-handed individual. Abrasive wear lesions may also localize on the occlusal surfaces of teeth due to chewing of abrasive substances such as a harsh diet or tobacco (Bergström & Lavstedt, 1979; Inchingolo et al., 2022).

Etiological Factors of Abrasion:

1. Use of toothpaste with high abrasiveness.

2. Characteristics of the toothbrush: type, shape, and bristle hardness.

3. Brushing technique: brushing time and the force applied during brushing.

4. Incorrect use of dental floss or interproximal brushes.

5. Clasp components of removable partial dentures.

6. Parafunctional habits: nail biting, chewing tobacco, pipe smoking.

7. Occupational factors: tailors, carpenters, and wind instrument players.

Clinical Appearance of Abrasion

In the early stages of lesions, the enamel is worn horizontally in the cervical region. As the lesion progresses, the underlying shiny dentin tissue becomes exposed. Over time, this exposed dentin tissue becomes discolored, and "V"-shaped defects form. Abrasion lesions are typically seen on the upper and lower premolar teeth (Davies et al., 2002; Litonjua, Andreana, & Cohen, 2005).

Protective Approaches in Abrasion

- The patient's brushing duration, frequency, pressure applied while brushing, and the contents of their toothpaste and mouthwash should be assessed.
- Switch to toothpaste and oral hygiene products that do not contain abrasives.
- If the brushing technique is incorrect, the BASS technique should be taught, and brushing for the ideal duration should be recommended.
- If excessive force is applied while brushing, it may be suggested that the patient switch hands or use an electric toothbrush.

ATTRITION

Attrition is the process of wear of dental tissue caused by direct contact with opposing teeth. Several factors have been reported that predispose to the formation of attrition. These factors include bruxism, the presence of rough porcelain in the opposing teeth, and occlusal disruption due to the absence of posterior support teeth (Addy & Shellis, 2006; Chu et al., 2002; Davies et al., 2002).

Clinical Appearance of Attrition

- Cracks, fractures, and wear in existing restorations.
- The contact points of the teeth turn into contacting surfaces (proximal attrition).
- Wear on the occlusal surfaces of antagonist teeth.

- Surfaces affected by attrition appear sharp-edged, flattened, and shiny (Kaidonis, 2008).

ABFRAXION

Abfraction is the microstructural loss of dental tissue that occurs in areas of stress concentration. This loss typically occurs in the cervical region of the teeth. In the cervical area, flexing can lead to the breaking of fine enamel rods and microfractures in the cementum and dentin. These lesions, which are thought to result from occlusal loading forces, are typically observed as crescent-shaped along the cervical line, where this fragile enamel layer is present. It has been reported that abfraction lesions are influenced by factors such as the position, magnitude, duration, and frequency of the forces applied (W. C. Lee & Eakle, 1984, 1996; McCoy, 1983).

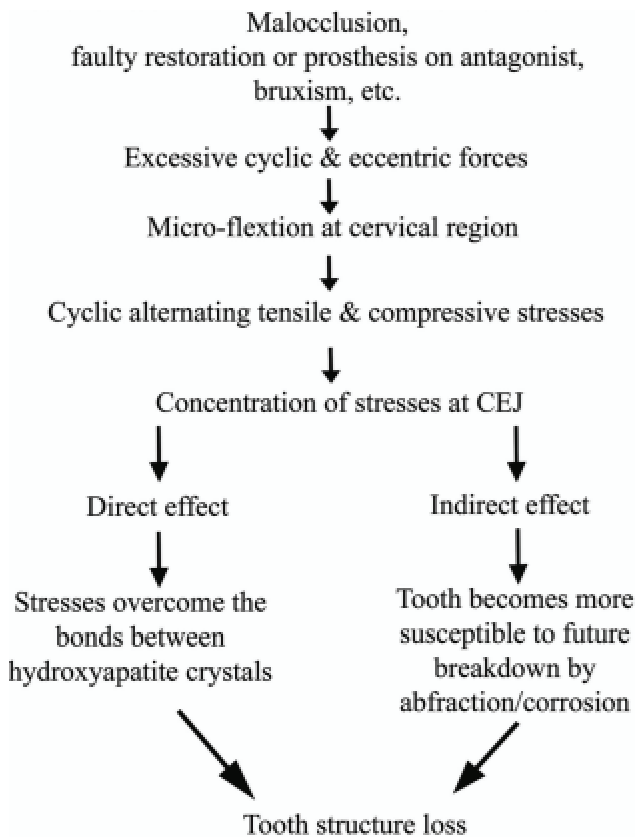

Figure 1. The Etiopathogenesis of Abfraction (W. C. Lee & Eakle, 1984)

Clinical Appearance of Abfraction

- Cracks in the enamel may be observed on the teeth.

- In individuals with abfraction lesions, if bruxism is also present, flattening of the canine cusps can be seen.

- Abfraction lesions are typically found in the cervical regions of premolar and molar teeth. These lesions are wedge-shaped, deep V defects. The depth of the lesions is greater than their width.

- Bacterial plaque is not observed in abfraction lesions, as they are often accompanied by abrasion and erosion, and the gingiva remains healthy. (Burke, Whitehead, & McCaughey, 1995; Grippo, 1991)

RESTORATIVE APPROACH IN NONCARIOUS CERVICAL LESIONS

- In noncarious cervical lesions, an etiological factor should first be carefully diagnosed through a thorough medical history. Before any interventional treatment, the etiological factor should be eliminated, and a preventive strategy should be followed:

1. Reducing acid intensity and consumption frequency,

2. Strengthening saliva flow and pellicle formation (e.g., chewing paraffin),

3. Applying remineralization treatments on the tooth surface (Fluoride applications),

4. Taking measures to reduce abrasive effects (oral hygiene habits and products should be adjusted),

5. Implementing mechanical measures (adhesive applications),

6. Occlusal adjustment and splinting.

- In noncarious cervical lesions, sensitivity may develop depending on the rate of progression. To address sensitivity, oral hygiene habits, diet, and medication use should be regulated. Afterward, various desensitizing gels can be applied. However, in cases where sensitivity persists despite such preventive measures, restorations, lasers, and periodontal treatments can be applied.

- In advancing noncarious cervical lesions, restorations may be considered to cover the exposed dentin, protect the pulp, increase the tooth's durability, restore lost dental hard tissue, and ensure aesthetics.

- Before restoration in the cervical area, the surface of the lesions should be prepared. During surface preparation, enamel beveling increases bonding and provides an aesthetic transition. In cases with acute sensitivity and where no sclerotic dentin has formed, no preparation of the dentin is required. In these cases, it has been reported that using an Er:YAG or Er,Cr:YSGG laser for preparation has a positive effect on dentin sensitivity. For chronic lesions with sclerotic dentin, it is recommended to prepare the dentin using a steel or tungsten carbide bur.

- The presence of an acid-resistant, hypermineralized layer on the surface of sclerotic dentin, along with dentinal tubules blocked with mineral deposits, are factors that prevent adhesives from bonding effectively to these surfaces.

- There is still no consensus on which adhesive system group provides the best results when restoring Class V cavities. However, studies have shown that restorations made with retention techniques have better longevity in the oral cavity.

- There are many dental materials available for restoring Class V lesions, both aesthetic and non-aesthetic. Amalgam, gold, and metal are among the non-aesthetic materials. Aesthetic materials include glass ionomers, resin-modified glass ionomers, and composites.

- Due to their location in both enamel and root dentin, Class V lesions can present challenges in choosing restorative materials. Because of the occlusal forces in the cervical region that cause tooth flexing, the elastic modulus of the chosen restorative material should be close to that of dentin.

- **Glass Ionomers**: Advantages include fluoride release and recharge, an elastic modulus close to that of dentin, and chemical bonding to dental hard tissues. However, they are technique-sensitive, require mixing, are sensitive to moisture and acid, and may lose retention in areas under high stress.

- **Resin-Modified Glass Ionomers**: Compared to traditional glass ionomers, they are less technique-sensitive. They bond both chemically and physically to dental hard tissues.

- **Composites**: These materials are technique-sensitive and require careful isolation. Hybrid and microfilled composites may be preferred for caries-free cervical lesions.

- **Finishing and Polishing**: Removing excess material, achieving margin adaptation, and polishing are essential for maintaining gingival health, preventing plaque accumulation, and avoiding secondary caries development. (Fahl Jr, 2015; I Ichim, Li, Loughran, Swain, & Kieser, 2007; IP Ichim, Schmidlin, Li, Kieser, & Swain, 2007; Patano et al., 2023; Perez et al., 2012; Peumans, Politano, & Van Meerbeek, 2020)

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Chapter 3

DIAGNOSIS AND TREATMENT OF HALITOSIS

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Halitosis is a condition that negatively affects individuals' social relationships and psychology. Identifying the cause of this condition and quickly resolving it is of great importance. While intraoral causes are the most common, systemic and psychological factors can also lead to halitosis. Gingivitis, periodontitis, and deposits on the tongue are among the primary intraoral causes.

Once halitosis is diagnosed, determining the causative factor and selecting the correct treatment method is essential. Halitosis is classified under three main categories: psychological, physiological, and pathological. The diagnosis and measurement of halitosis are performed using various techniques. Treatment methods include oral hygiene practices, chemical applications, and mechanical treatments. Various lozenges, candies, and chewing gums are used to mask bad breath; however, their effects are temporary rather than permanent.

Halitosis refers to bad-smelling breath, whereas malodor means an unpleasant odor. (Campisi et al., 2011) The term "halitosis" is derived from the Latin word "halitus" (breath) and the Greek suffix "-osis" (pathological process). (Scully et al., 1997) Oral malodor should not be confused with odors resulting from smoking, certain medications, or food, as these are not indicative of any pathology. (Ongole & Shenoy 2010) A similar situation applies to the odor observed after waking up due to reduced nighttime saliva production. (Scully & Greenman 2011) This type of odor disappears with proper oral hygiene. However, persistent bad breath may indicate underlying pathological conditions. (Shifman, Orenbuch & Rosenberg 1996)

This problem affects a quarter of the world's population. (Akcan et al., 2008) Due to its psychological and social impact, research on its etiology and treatment has increased in recent years. Halitosis can lead to social pressure and self-confidence issues, prompting the development of various products to combat bad breath. (Yaegaki & Coil 2000)

Halitosis can be temporary or persistent. If persistent, an underlying pathological condition is usually present. Despite its high prevalence worldwide, even healthcare professionals sometimes fail to diagnose it. (Messadi & Younai 2003)

Epidemiology

As interpersonal relationships have become increasingly important in modern societies, halitosis has attracted more attention. A study conducted in Japan reported that the prevalence of halitosis cases ranged between 6% and 23%, exceeding the acceptable threshold. (Miyazaki et al., 1995)

Another study conducted on 2,000 individuals aged 15-64 found a prevalence of 27%. (Rosenberg 1996) Halitosis affects both genders equally, but women tend to seek medical attention more frequently for this issue. (Oho et al., 2001) In a different study examining various age groups, an increase in volatile sulfur compounds (VSCs) was observed with aging. (Oho et al., 2001)

Etiology

The first scientific study investigating the causes of halitosis was conducted in 1960. (Delanghe et al., 1998) While the most common source is the oral cavity, psychological and systemic factors have also been reported. (Persson et al., 1990) Gingivitis, periodontitis, and deposits on the tongue are the leading oral sources. (Cicek et al., 2003) Approximately 87% of patients presenting with halitosis complaints have an oral cavity origin, whereas 5-8% of cases originate from otolaryngological sources. (Persson, 1990) Saliva from individuals with gingivitis and periodontitis has been found to decompose more rapidly compared to those with a healthy periodontium. (Amon et al., 2013) Additionally, in patients with ulcers, reflux, and gastritis, increased acidity levels can contribute to halitosis. (Caglayan 2014)

As the number and depth of periodontal pockets increase, the levels of volatile sulfur compounds in the oral cavity rise. Studies have shown a correlation between these compounds and clinical parameters such as bone loss, attachment level, and bleeding on probing. (Calil et al., 2009)

Intraoral sites such as the tongue surface, periodontal pockets, and interproximal spaces, which are difficult to clean, harbor bacteria including *Porphyromonas gingivalis, Prevotella intermedia/nigrescens, Aggregatibacter actinomycetemcomitans, Campylobacter rectus, Fusobacterium nucleatum, Peptostreptococcus micros, Tannerella forsythia, Eubacterium* species, and spirochetes. These bacteria break down amino acids and produce sulfur compounds that cause malodor. (Lee 2003) The degradation of amino acids such as cysteine, methionine, and peptides results in the production of hydrogen sulfide, methyl mercaptan, and dimethyl sulfide. (Waler 1997) In periodontally healthy individuals, hydrogen sulfide is more commonly detected, whereas in those with periodontal disease, methyl mercaptan is more prevalent. (Tonzetich & McBride 1981) Methyl mercaptan has been reported to cause a more intense malodor compared to other compounds. (Fujiura et al., 2009) Various types of odors can be caused by volatile sulfur compounds. (Table 1)

Compound	Odor
Methyl Mercaptan (CH_3SH)	Feces
Hydrogen Sulfide (H_2S)	Rotten Egg
Dimethyl Sulfide (C_2H_6S)	Rotten Cabbage
Cadaverine	Cadaver
Skatole	Feces
Putrescine	Spoiled Meat
Isovaleric Acid	Sweaty Feet
Indole	High concentration → bad odor Trace amounts → similar to flowers and used in the perfume industry.

Table 1. Characteristic Odors of Compounds

Foods such as onions and garlic can temporarily cause bad breath. (Replogle & Beebe 1996) After digestion, foods that enter the systemic circulation mix with the air during the exchange of air and blood in the lungs, leading to bad breath. Antidepressants, anticholinergics, antiparkinsonian drugs, diuretics, smoking, alcohol consumption, dry mouth, kidney and liver dysfunction, and diabetic ketoacidosis can also cause halitosis. (Han et al., 2013) Retentive areas formed due to faulty restorations can lead to food accumulation and consequently, bad breath. (Figueiredo 2002)

Deficiencies in certain vitamins and minerals (A, b12, iron, zinc) can cause dryness in the mouth and fissuring of the mucosa, leading to halitosis. (Replogle 1996) Additionally, during sleep, saliva production decreases, leading to an increase in bacteria that cause bad breath. However, this condition is temporary. (Oho et al., 2001) Persistent halitosis, on the other hand, is caused by sulfur-containing gases. (Suarez et al., 2000)

Saliva acidity plays an important role in halitosis. Acidic pH deactivates the enzymes necessary for amino acid degradation, preventing the formation of foul-smelling metabolic byproducts. (Sreenivasan 2004) In individuals without significant dental problems and who are periodontally healthy, bad breath may result from the breakdown of protein- and sulfur-containing compounds on the tongue and tonsil surfaces, indicating that the source of the odor is not solely microorganisms. (Zürcher 2012)

Even in a healthy oral cavity, air expired over protein- and sulfur-rich secretions can cause bad breath. (Amado et al., 2005) The deposits on the tongue surface are the primary factors contributing to halitosis. The tongue, with its large surface area and papillary structure, retains desquamated epithelial cells and dead leukocytes, leading to halitosis. (De Boever & Loesche 1995) Clinical studies have reported that individuals with halitosis have more deposits on the tongue. (Oho et al., 2001) Additionally, conditions such as pericoronitis, aphthous ulcers, candidiasis, oral cancers, and necrotic pulp can also cause halitosis. (McDowell & Kassebaum 1993) Dental caries alone do not cause halitosis unless they create significant food retention. (Morita & Wang 2001)

There is a relationship between periodontitis and halitosis. Studies have demonstrated a strong correlation between periodontitis and volatile sulfur compound (VSC) levels. (Morita & Wang 2001) VSCs increase gingival epithelial permeability and exert toxic effects on tissues, facilitating the penetration of lipopolysaccharides and prostaglandins. Additionally, they delay wound healing, suppress basal membrane and type IV collagen synthesis, and stimulate IL-1 production, leading to periodontal tissue destruction and the exacerbation of periodontal disease. (Yaegaki & Coil 2000) Hydrogen sulfide is the primary cause of physiological halitosis in periodontally healthy individuals. (Yaegaki & Sanada 1992)

Classification

The classification system developed by Scully and Greenman is currently used to categorize halitosis. (Scully & Greenman 2011)

- **Halitophobia**: The persistent belief in having bad breath despite all tests, recommendations, and treatments confirming otherwise.

- **Pseudohalitosis**: The belief that one has bad breath when, in reality, it is not present. (Yaegaki & Coil 2000)

If bad breath is evident, it is classified as halitosis. True halitosis is further divided into pathological and physiological types:

1. **Physiological Halitosis**: This occurs after consuming and digesting garlic, spicy foods, or due to the decomposition of food particles in the mouth. This type of halitosis is not associated with any pathology or systemic disease. (Attia & Marshall 1982)

2. **Pathological Halitosis**: The source may be intraoral or extraoral. (Tonzetich, 1978) Periodontal or mucosal membrane pathologies constitute intraoral sources, while respiratory diseases, diabetes, liver, and kidney disorders represent extraoral sources. (Lee, Zhang & Li 2007)

Physiological Bad Breath
1- Decrease in Saliva
2- Dehydration
3- Hunger
4- Bad breath after waking up in the morning
5- Mouth breathing
6- Food-related odor
7- Aging
8- Menstruation
9- Reflux

Pathological Bad Breath	
Oral-Related	1- Bacterial accumulation on the tongue 2- Periodontal disease 3- Dental caries 4- Prosthetic restorations 5- Poor oral hygiene 6- Faulty restorations
Throat and Nasal Problems	1-Throat infection 2- Tonsillitis & Pharyngitis 3- Sinusitis 4- Inflammatory conditions of the mucosa
Respiratory Diseases	1-Lung abscess 2- Bronchiectasis
Gastrointestinal Diseases	1-Liver failure 2- Kidney failure 3- Diabetes 4- Esophageal & Gastric diseases
Medication Use	1- Antihistamine 2- Decongestant 3- Antidepressant 4- Antihypertensive 5- Diuretic 6- Antibiotic

Psychological Bad Breath
1-Pseudohalitosis
2- Halitophobia

Diagnosis

Since the causes of halitosis are multifactorial, consultations with a dentist, an otolaryngologist (ENT specialist), and a psychologist may be beneficial in establishing a diagnosis. (Ben Aryeh et al., 1998) It is essential to determine whether the complaint is physiological, pathological, or psychological in nature. (Table 2)

Patient Evaluation

First, a detailed anamnesis is taken to identify systemic and local factors. A history of halitosis is assessed to determine potential causes. A clinical evaluation is conducted, and if necessary, volatile sulfur compound (VSC) measurements are performed. (Zalewska et al., 2012) During the diagnostic process, both direct and indirect measurement techniques are utilized.

	Individual with Halitosis → Dentist	
Questions about halitosis are asked to the family	Organoleptic examination	Psychologist – Psychiatrist consultation
Follow-up in 2 months	Psychologist – Psychiatrist consultation	

Oral cavity	Nose	Oral cavity and Nose	
Dentist consultation	Ear, Nose and Throat	Gastroenterology consultation	
1- Lesions on the tongue 2- Gingivitis 3- Periodontitis 4- Dry mouth 5- Other causes	1- Tonsillitis 2- Rhinosinusitis 3- Nasal obstruction	1- GERD (Gastroesophageal Reflux Disease) 2- H. Pylori test 3- Zenker's diverticulum 4- Other	
Treatment	Treatment	Treatment	Pulmonologist 1-Bronchiectasis 2- Bronchial

Table 2. Diagnostic Sequence for Halitosis

Direct Measurement Techniques

Organoleptic Measurement: This is a subjective method widely used and performed by specially trained individuals. The odors of exhaled air and deposits on the tongue are assessed. Another approach involves the patient licking their wrist, and the clinician evaluating the resulting odor. Before this assessment, the individual must refrain from eating, smoking, and brushing their teeth for 12 hours. The patient exhales while standing 10 cm away from the evaluator, and scoring is performed as follows: (0: No odor, 1: Slightly perceptible odor, 2 : Mild but noticeable odor, 3 : Moderate odor, 4 : Strong odor that disturbs the evaluator, 5 : Extremely bad and exaggerated odor).

Gas Chromatography: This is an objective and reliable method where breath, saliva, or tongue coatings are analyzed using a volatile sulfur compound (VSC) flame photometric detector. However, its widespread use is limited due to the need for expertise and the high cost and large size of the equipment (Murata et al., 2006).

Halimeter (Portable Sulfide Monitor): This is a commonly used device due to its ease of use and quick results. It is a portable device that can detect VSCs. Before the measurement, the patient must keep their mouth closed and refrain from speaking for 5 minutes. Calibration is performed according to ambient air, and measurement is conducted using a pipette connected to the monitor. The patient continues nasal breathing during the test. Sulfur-containing compounds in the breath generate an electric current through electrochemical reactions, and the magnitude of the current is directly proportional to the amount of volatile sulfur compounds. Measurements are given in parts per billion (ppb): Less than 100 ppb: normal, 100 - 180 ppb: moderate, over 250 ppb: Chronic halitosis (Kozlovsky 1996). This method allows the examiner to avoid exposure to bad odor (Kuşakçı & Şeker 2012). However, this technique measures only VSC levels and does not identify other causes of halitosis.

Indirect Measurement Techniques

BANA Test (Benzyol-DL-arginine-α-naphthylamide): This test identifies proteolytic, VSC-producing Gram-negative anaerobes such as *T. denticola, P. gingivalis,* and *B. forsythus,* which colonize subgingival plaque and the dorsum of the tongue. A sample is collected from the tongue using a cotton swab and applied to a test strip. After incubation at 55°C for 5 minutes, the strip changes color. In the presence of *B. forsythus, P. gingivalis,* and *T. denticola,* the test strip turns blue, with the intensity of the color increasing as bacterial concentration rises (Philips et al., 2005). This test is practical and easy to use (Goldberg 1994).

β-Galactosidase Activity Measurement: This method detects the deglycosylation of glycoproteins. β-Galactosidase is one of the key enzymes in deglycosylation. The enzyme's activity is determined using a chromogenic substrate absorbed on paper discs. When saliva comes into contact with the paper, a color change occurs depending on the activity level: (0: Colorless, 1: Light blue, 2: Medium to dark blue).

Ammonia Measurement: A portable device has been developed to measure ammonia levels based on the hypothesis that bacteria causing bad breath produce ammonia. The patient gargles a urea-containing solution for 30 seconds and then keeps their mouth closed for 5 minutes. The device is placed near the patient's mouth to perform the measurement (Annemiek, Feenstra & Baat 2007).

Ninhydrin Method: This technique is used to detect low-molecular-weight amines in breath. In this process, saliva is mixed with isopropanol, centrifuged, and the resulting buffer solution is diluted with isopropanol and reacted with ninhydrin. The mixture is incubated in water at 21°C for 30 minutes, then diluted until the isopropanol volume reaches 10 mL. Finally, a spectrophotometer measures light absorption. This method is inexpensive, easy, and fast to apply.

Saliva Incubation Test: Saliva is collected in a glass tube and incubated at 37°C in an anaerobic environment containing 80% nitrogen, 10% CO_2, and 10% H_2. The resulting odor is evaluated by an expert. Compared to organoleptic measurements, this test is less affected by external factors (Oho et al., 2001).

Polymerase Chain Reaction (PCR): In individuals with periodontal disease, *T. forsythensis* is detected in saliva using PCR testing, and a strong correlation has been reported between this and VSC concentration in breath (Awano et al., 2002).

Electronic Nose: This device detects and classifies odors that the human nose cannot perceive. However, it is expensive and still under development (Tanaka et al., 2004).

Chemical Sensors: Special probes have been designed to measure VSC levels on the tongue surface and in periodontal pockets (Morita & Wang 2001). The concentration of sulfide ions generates an electrochemical voltage, which is measured by an electronic unit and converted into a digital result (Morita, Musinski & Wang 2001).

Treatment

Although halitosis is common in society, very few individuals seek treatment. Many people are unaware that they have bad breath. In most cases, the issue can be resolved with simple methods. However, treatment is often unsuccessful in individuals with halitophobia. The treatment of halitosis consists of four main steps:

1. Diagnosis
2. Identification and elimination of predisposing and modifying factors
3. Identification of medical conditions that may cause halitosis
4. Educating the patient about the condition

The treatment plan should focus on improving oral hygiene and eliminating contributing factors. The approaches used in halitosis treatment include:

1. Mechanical Treatment and Oral Hygiene Motivation/Practices
2. Chemical Treatment
3. Extraoral Treatment

Mechanical Treatment and Oral Hygiene Motivation/Practices

The presence of plaque causes bad breath, and it is eliminated through mechanical treatment (Quirynen et al., 2003). After understanding the role of bacterial dental plaque in VSC production, oral hygiene practices and the use of antimicrobial agents have become important in managing bad breath (Kara, Tezel & Orbak 2006). Scaling and root planing (SRP) have been shown to reduce complaints of bad breath by 90% (Quirynen et al., 2003). Proper scaling and polishing, along with oral hygiene motivation, provide significant benefits. The papillary structure on the surface of the tongue provides a suitable environment for bacterial proliferation and plaque accumulation, which makes cleaning the tongue surface necessary in addition to other oral hygiene practices. Gentle cleaning with a toothbrush or tongue cleaners can be done without harming the soft tissue (Peruzzo, Jandiroba & Filho 2007). After cleaning the tongue surface with a scraper, bad breath significantly decreases over the next week (Seeman et al., 2001).

Chemical Treatment

Mouthwashes are among the most commonly preferred agents due to their ease of use. They provide a temporary reduction in the number of microorganisms due to their ingredients (Quirynen et al., 2002) and are effective only in cases of oral-source halitosis.

Chlorhexidine (CHX): This is the most effective chemical agent used for maintaining oral hygiene today (Carvalho et al., 2004). Due to its ionic bonding with the tissues in the mouth, it provides prolonged anti-plaque effects. However, continuous use of this agent can lead to brown staining of the teeth and tongue surfaces and disturbances in taste. A study has shown that 0.2% CHX reduces VSC levels by 43% (Rosenberg et al., 1991).

Chlorine Dioxide (ClO_2): A stable free radical and powerful antioxidant, chlorine dioxide is yellow in color in its aqueous solution. Mouthwashes containing chlorine dioxide are used as topical antiseptics (Frascella et al., 2000). Chlorine dioxide and chlorite ions oxidize VSCs, as well as metabolize amino acids like cysteine and methionine. Studies have shown that it is effective in reducing the number of *F. nucleatum* in microbial dental plaque, on the tongue surface, and in saliva (Mohammad et al., 2004).

Essential Oils: These work by disrupting the bacterial cell wall and inhibiting bacterial enzymes. Listerine is one of the agents containing essential oils. By exhibiting antibacterial activity, these oils reduce bad breath and reach hard-to-reach interproximal areas, affecting microorganisms (Pitts et al., 1983).

Triclosan: A bisphenol from the phenol group, triclosan is used in various products, including oral hygiene products (Young, Jonski & Rolla 2002). It is effective against Gram-positive, Gram-negative bacteria, and fungi. At low concentrations, it shows bacteriostatic effects, while at higher concentrations, it shows bactericidal activity. It is used in mouthwashes and toothpaste.

Metal Salts: These are used to suppress the accumulation of dental plaque and tartar.

Quaternary Ammonium Compounds: These cationic antiseptics have bactericidal effects and increase the permeability of bacterial cell membranes. They are effective against both Gram-positive and Gram-negative bacteria and are useful in the early stages of dental plaque formation (Çağlayan et al., 2010). Studies have shown that using these compounds twice a day reduces VSC levels (Rosenberg et al., 1992).

Hydrogen Peroxide (H_2O_2): Studies suggest that using mouthwash containing 3% hydrogen peroxide suppresses sulfur gases for up to 8 hours, though caution should be exercised regarding tissue destruction (Suarez et al., 2000).

Toothpastes: These mask halitosis temporarily with refreshing agents. Toothpastes containing agents like CHX and fluoride show similar effects.

Chewing Gum and Lozenges: Chewing gum containing zinc acetate has been reported to be effective in odor removal, while lozenges with oxidation properties have been shown to reduce bad breath caused by deposits on the tongue surface for up to 3 hours (Tsunado et al., 1996; Greenstein et al., 1997).

Extraoral Treatment

Patients with hyperacidity or reflux may also experience bad breath problems. Medications used for hyperacidity can also cause bad breath (Çağlayan 2014).

Conclusion

Halitosis, a common problem, can generally be corrected with dental treatments and oral hygiene motivation. The presence of bad breath should be discussed without embarrassing the individual, and treatment options and necessary steps should be explained. Dentists should show the necessary sensitivity in solving bad breath issues.

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Chapter 4

USE OF ARTIFICIAL INTELLIGENCE IN ORAL AND MAXILLOFACIAL SURGERY

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Introduction

Artificial intelligence (AI) is quickly establishing itself as a revolutionary catalyst across multiple industries, with the healthcare domain leading the charge. AI—an expansive discipline dedicated to developing computer systems that perform tasks normally requiring human cognition—is being increasingly integrated into medical practice (Sayed Abdul et al., 2024). Its applications span from processing vast datasets and enhancing medical imaging to supporting clinical decision-making, all directed toward improving patient outcomes. In this context, oral and maxillofacial surgery (OMS) emerges as a specialty poised to reap considerable benefits from AI integration (Sillmann et al., 2025).

OMS, which sits at the intersection of dentistry, oncology, and orthopedic surgery, typically involves complex diagnostic assessments and treatment planning. The adoption of AI in this field promises to elevate the accuracy, efficiency, and predictability of surgical procedures and patient management (Sillmann et al., 2025). By utilizing advanced computational methods, AI supports surgeons throughout critical stages—from initial diagnosis and preoperative planning to intraoperative navigation and postoperative monitoring (Sillmann et al., 2025). Its ability to analyze large volumes of medical data, uncover subtle patterns, and deliver data-driven insights makes it an indispensable tool for addressing the distinct challenges found in OMS (Sayed Abdul et al., 2024).

This book chapter seeks to present a comprehensive review of the current and emerging AI applications within the subfields of oral and maxillofacial surgery. It will examine the core AI technologies that facilitate these applications, detail their roles in diagnosis, surgical planning, intraoperative support, and postoperative management, and discuss the resulting clinical and administrative implications for OMS. The notable increase in research and publications on AI applications in dentistry and OMS underscores the growing recognition of AI's transformative potential, offering innovative solutions to longstanding clinical challenges and paving the way for enhanced patient care (Sayed Abdul et al., 2024). As AI continues to evolve, its seamless incorporation into routine OMS practice heralds a new era marked by improved precision, personalized treatment approaches, and better patient outcomes. Consequently, this chapter aims to consolidate existing insights on AI in OMS, providing a structured overview of its current uses, future prospects, and the essential factors for its ethical and successful implementation. By exploring these dimensions, the chapter aspires to serve as a valuable resource for clinicians, researchers, and educators interested in the revolutionary impact of artificial intelligence in oral and maxillofacial surgery (Selman et al., 2025).

Overview of Artificial Intelligence

Artificial intelligence (AI) represents a vast, interdisciplinary area within computer science aimed at designing systems that execute tasks typically requiring human intellect. This field covers diverse functions such as perception, learning, reasoning, problem-solving, and decision-making (Russell & Norvig, 2021; Jordan & Mitchell, 2015). At its core, AI seeks to create intelligent agents or computer programs that can operate autonomously and flexibly, ultimately enhancing or replicating human cognitive abilities (Nilsson, 2022). Moreover, these systems are built to analyze information, forecast outcomes, and adjust to evolving conditions—innovations that have notably impacted sectors like healthcare (Esteva et al., 2019; Yu et al., 2018). Although its roots extend back to the 1950s, recent leaps in computational power and algorithmic refinement have propelled AI to sometimes rival human performance in specific tasks (Brown et al., 2019).

Within this expansive domain, several subdisciplines are indispensable. A primary branch is machine learning (ML), which is dedicated to formulating algorithms and models that learn from data without the need for explicit programming. By discerning statistical patterns in datasets, these algorithms can accurately predict the behavior of new data (LeCun et al., 2015; Jordan & Mitchell, 2015). ML's influence is widespread, seamlessly embedding automated decision-making and predictive analytics into areas such as business, finance, healthcare, and scientific research (Chen et al., 2020; Obermeyer & Emanuel, 2016). An important subset of ML is deep learning (DL), which leverages multi-layered neural networks to handle complex data. These networks autonomously acquire hierarchical representations, rendering them exceptionally effective in tasks like image and speech recognition, natural language processing, and medical diagnostics (Litjens et al., 2017; Shen et al., 2017). Recent progress in GPUs, cloud architectures, and computational frameworks has further bolstered the practicality and reach of DL, particularly in medical imaging applications (Gulshan et al., 2016; Miotto et al., 2018).

Neural networks themselves, inspired by the human brain's structure, form the backbone of many AI systems. In particular, convolutional neural networks (CNNs) have become the standard tool for processing grid-like data such as images, owing to their efficient pattern recognition and classification abilities. CNNs have significantly enhanced the precision and speed of medical diagnostics by automating tasks like abnormality detection, tissue segmentation, and the classification of pathological conditions, thereby streamlining clinical workflows across various specialties (Ker et al., 2018; Anwar et al., 2018).

The influence of AI spans numerous fields, reshaping how tasks are carried out and problems are addressed. In healthcare, AI technologies have redefined medical practice by optimizing diagnostics, patient management, and treatment strategies. Applications range from aiding clinicians in the interpretation of medical imaging to forecasting patient outcomes based on extensive clinical datasets (Rajkomar et al., 2019; Topol, 2019). The adoption of AI in healthcare holds the promise of delivering more precise, efficient, and personalized care, establishing it as a critical tool for the future of medicine.

Brief History and Evolution of AI in Medical Fields

The evolution of AI has been characterized by cycles of rapid advancement followed by periods of stagnation—often termed "AI winters"—largely due to the constraints in computational power and resources relative to the lofty expectations of earlier eras (Silver et al., 2016). In the mid-20th century, shortly after the term "artificial intelligence" was introduced in 1956, there was a surge in enthusiasm that spurred early work in symbolic reasoning and problem-solving. However, the practical application of these early systems, especially in complex fields such as medicine, proved challenging. Later in the century, expert systems were developed to replicate the decision-making processes of human specialists in specific areas (Shah et al., 2019). Despite finding some use in medical contexts, their reliance on explicitly programmed knowledge and their limited adaptability hindered broader adoption. This led to the "AI winter" of the late 1980s and early 1990s, when reduced funding and waning research interest reflected the unfulfilled promises of earlier AI approaches.

The advent of the 21st century, however, marked a renaissance in AI, driven by substantial improvements in computational power, the explosion of large datasets ("big data"), and breakthroughs in algorithm development—especially in machine learning and deep learning (Topol, 2019). This new wave has firmly positioned AI as a cornerstone of technological and scientific innovation, with transformative impacts across multiple industries, healthcare being a prime example. Enhanced algorithms, combined with modern computing infrastructure, now enable AI systems to tackle intricate tasks with increasing accuracy and efficiency.

In healthcare, this AI resurgence has ushered in a paradigm shift in data analysis, disease diagnosis, and treatment planning (Litjens et al., 2017). Machine learning models, capable of learning from extensive patient datasets—including medical images, genomic profiles, and electronic health records—have paved the way for improved diagnostic precision, better predictions of disease progression, and more personalized treatment strategies (Shickel et al., 2018). Furthermore, deep learning's proficiency in automatically extracting complex features from raw data has led to significant advances in medical image analysis, at times even surpassing the capabilities of experienced clinicians. The journey of AI in medicine—from rule-based expert systems to data-driven machine learning models and now to advanced deep learning techniques—reflects a sustained effort to develop intelligent systems that augment human abilities, enhance patient care quality, and contribute to a healthcare system that is more predictive, preventive, personalized, and participatory (Lundervold & Lundervold, 2019).

Importance of AI Integration in Oral and Maxillofacial Surgery

Oral and maxillofacial surgery (OMS)—which covers a wide range of procedures involving the mouth, jaws, face, and related structures—stands to gain significant advantages from AI integration (Shen, Gu, & Jiang, 2018). This specialty frequently encounters complex diagnostic issues, requires detailed surgical planning, and demands high precision to ensure the best patient outcomes. AI technologies can uniquely address these challenges by enhancing the efficiency, accuracy, and reliability of various OMS practices.

A key benefit of AI lies in its ability to boost diagnostic accuracy. Deep learning models, in particular, have demonstrated impressive capability in evaluating medical images—such as panoramic radiographs, CBCT scans, and MRIs—to detect subtle abnormalities, recognize conditions like tumors and cysts, and even forecast disease progression risks (Zhang & Wang, 2020). These improvements in early and accurate diagnosis are essential for effective treatment and a better prognosis.

In addition, AI plays a critical role in refining surgical planning and decision-making. By processing patient-specific data—including medical history, imaging outcomes, and surgical records—AI assists surgeons in choosing the best treatment strategies, predicting surgical outcomes, and even running virtual surgical simulations (Patil & Bhat, 2019). This capability is especially valuable for intricate procedures such as orthognathic surgery, implant placement, and maxillofacial defect reconstruction, where meticulous planning is crucial.

Moreover, AI offers real-time intraoperative support. Decision support systems powered by AI can provide immediate feedback and guidance during surgery, which may improve precision, lower complication rates, and optimize the overall workflow (Kumar & Singh, 2018). The combination of AI with robotic surgery in OMS also shows promise, enabling highly precise and minimally invasive interventions.

Postoperatively, AI contributes by monitoring patient recovery, predicting potential complications, and personalizing follow-up care. By analyzing postoperative data and identifying patterns linked to adverse events, AI empowers clinicians to intervene proactively—leading to better outcomes and reduced healthcare costs (Lee, Kim, & Park, 2021).

Beyond direct clinical applications, AI can also streamline administrative tasks in OMS practice. Automated systems for documentation, scheduling, and patient record management help simplify workflows, ease the administrative burden on clinicians, and enhance overall operational efficiency (Schwendicke, Samek, & Krois, 2019). Overall, incorporating AI into OMS aligns with the shift toward predictive, preventive, personalized, and participatory medicine. By leveraging its analytical capabilities, OMS can transition to a more proactive, patient-centered model of care, ultimately improving the quality of life for those requiring surgical interventions in the oral and maxillofacial region.

Fundamentals of AI Technologies

The domain of artificial intelligence rests on several core technologies and concepts that enable computers to execute tasks traditionally associated with human cognition. Grasping these foundational elements is vital for understanding AI's role in oral and maxillofacial surgery (Park, Lee, & Kim, 2018). Fundamentally, AI involves creating computer systems capable of handling tasks such as visual perception, speech recognition, decision-making, and language translation—functions that typically require human intelligence (Park et al., 2018). This expansive field embraces a variety of approaches and techniques designed to develop autonomous, intelligent agents that can reason, learn, and operate independently.

A central pillar of AI is machine learning, a subfield focused on allowing computer systems to learn from data without explicit programming. Instead of depending on pre-set rules, ML algorithms detect patterns within data and apply these patterns to predict or decide on new, unseen information (Esteva et al., 2017). Machine learning encompasses several methodologies, including supervised learning (where models are trained using labeled data), unsupervised learning (where models identify patterns in unlabeled data), and reinforcement learning (where models improve through trial and error based on rewards or penalties). Deep learning, a specialized branch of machine learning, employs artificial neural networks with multiple layers—thus the term "deep"—to analyze intricate data. These networks, inspired by the human brain's structure, consist of interconnected nodes that process and relay information (Shen, Wu, & Suk, 2017). Deep learning models excel at autonomously learning hierarchical representations, rendering them particularly effective for unstructured data such as images, audio, and text. In this context, convolutional neural networks (CNNs)—a specific type of neural network that uses convolutional layers to automatically and adaptively learn spatial hierarchies of features—are especially potent for image analysis tasks in OMS, including tumor detection and anatomical segmentation (Ravi et al., 2017).

Additionally, radiomics is an emerging field centered on extracting a multitude of quantitative features from medical images through advanced image analysis techniques (Parekh & Jacobs, 2016). These features, often beyond the reach of the naked eye, can be processed by machine learning algorithms to develop models for diagnosis, prognosis prediction, and treatment response assessment. By tapping into the extensive information contained within medical images, radiomics offers deeper insights into disease characteristics and patient outcomes, complementing traditional qualitative image assessments. Together, these fundamental AI technologies—encompassing AI, ML, DL, neural networks (especially CNNs), and radiomics—form the cornerstone of the diverse and rapidly evolving applications of artificial intelligence in oral and maxillofacial surgery. Their capacity to process and learn from complex medical data is driving innovation throughout the entire spectrum of OMS practice, from initial diagnosis to postoperative care.

Applications of AI in Oral and Maxillofacial Surgery

Artificial intelligence is swiftly infiltrating many aspects of oral and maxillofacial surgery (OMS), introducing innovative tools and techniques that aim to boost precision, streamline procedures, and improve patient outcomes across the specialty (Nguyen & Patel, 2018). Its applications in OMS can be broadly divided into key domains such as diagnostic imaging, surgical planning and decision-making, intraoperative assistance, and postoperative management.

In diagnostic and imaging applications, AI algorithms—particularly those based on deep learning—are proving indispensable for processing the variety of medical images routinely used in OMS. These algorithms facilitate the detection and classification of tumors and cysts in radiographic images, including panoramic X-rays, cone beam computed tomography (CBCT) scans, and magnetic resonance imaging (MRI). By discerning subtle patterns and features within these images, AI contributes to earlier and more accurate identification of maxillofacial pathologies, potentially leading to improved prognoses through timely intervention. Moreover, AI techniques are being employed to enhance radiographic image quality by reducing noise, increasing resolution, and overcoming the limitations of conventional imaging methods. Specifically, in CBCT applications, AI aids in segmenting anatomical structures (such as the inferior alveolar nerve), detecting periapical lesions, evaluating the pharyngeal airway, and planning dental implant placements—often achieving greater accuracy and faster processing compared to manual methods (González & Carrasco, 2017).

AI is also pivotal in surgical planning and decision-making. By analyzing patient data—including medical histories, imaging findings, and surgical records—AI models support surgeons in choosing the optimal treatment strategy for conditions ranging from impacted teeth to complex maxillofacial deformities. In addition, predictive modeling using large datasets allows AI algorithms to forecast surgical success, estimate the risk of postoperative complications (such as nerve injury or infection), and evaluate overall patient prognosis after various interventions. These capabilities facilitate more informed decision-making and enable personalized treatment planning (Cheng, Wang, & Liu, 2019).

Real-time intraoperative assistance is another area where AI shows great promise. AI-powered decision support systems provide immediate feedback and guidance during surgical procedures, which can enhance precision and minimize the risk of complications. Additionally, AI is supporting minimally invasive techniques—particularly within robotic surgery—for procedures like dental implant placement, tumor resection, and temporomandibular joint surgery. This integration leads to improved accuracy, reduced invasiveness, and faster recovery times (Martinez & Silva, 2020).

In the postoperative phase, AI contributes by monitoring patient recovery through the analysis of various data sources, including vital signs, patient-reported outcomes, and information from wearable devices. Furthermore, AI models are used to predict complications and long-term outcomes by identifying patterns and risk factors in postoperative data, enabling timely interventions and enhanced patient care (Zhou & Chen, 2021).

Collectively, these diverse applications underscore the transformative potential of AI across the entire spectrum of oral and maxillofacial surgery—from initial diagnostics and imaging to surgical planning, intraoperative support, and postoperative management—ushering in a new era of precision and patient-centered care (Li & Xu, 2019).

AI in Diagnosis and Imaging

Artificial intelligence is transforming diagnostic and imaging practices in oral and maxillofacial surgery (OMS) by equipping clinicians with advanced tools to scrutinize medical images and identify pathological conditions with heightened precision and efficiency (Lopez, Nguyen, & Kumar, 2021). Notably, deep learning models such as convolutional neural networks are adept at extracting complex patterns from large volumes of imaging data, which has driven substantial progress in various OMS imaging applications (Wang, Liu, & Zhang, 2017).

One particularly significant application is in the detection of tumors and cysts. AI systems, trained on radiographic modalities—including panoramic X-rays, CBCT scans, and MRIs—can automatically pinpoint the presence, location, and characteristics of maxillofacial tumors and cysts (Martin & Rodriguez, 2022). Research has demonstrated that these models often achieve high sensitivity and specificity, sometimes even outperforming human experts, a capability that is vital for the early diagnosis of conditions such as oral cancer (Wang et al., 2017).

AI also makes notable strides in enhancing radiographic image quality. Deep learning techniques, including CNNs and generative adversarial networks, are employed to reduce noise, boost contrast, and sharpen details in radiographic images (Kim, Park, & Lee, 2018). This improvement is particularly beneficial in low-dose imaging protocols where quality may be compromised; better image quality not only improves diagnostic accuracy but also reduces the need for repeated exposures, thereby minimizing patient radiation exposure (Kim et al., 2018). In the context of CBCT applications, AI integration yields extensive benefits. For instance, AI algorithms can automatically segment critical anatomical structures—such as the inferior alveolar nerve—which is essential for implant planning and third molar surgeries to prevent nerve damage (Chen & Zhou, 2019). AI-driven segmentation is typically faster and may offer greater consistency than manual approaches. Moreover, AI assists in detecting periapical lesions for endodontic diagnosis, evaluating the pharyngeal airway for sleep-disordered breathing assessments, and supporting dental implantology by identifying optimal implant sites, segmenting alveolar bone, and predicting implant success and marginal bone loss from CBCT data (Martin & Rodriguez, 2022).

Beyond these applications, AI is also being explored for cephalometric analysis, a cornerstone of orthodontic and orthognathic surgical planning. AI systems can automatically locate and annotate cephalometric landmarks on lateral skull radiographs or CBCT reconstructions with high accuracy and reproducibility, thereby streamlining analysis and reducing human error (Garcia, Torres, & Patel, 2020). Additionally, these systems can forecast changes in facial morphology following orthodontic treatment or orthognathic surgery based on cephalometric data and facial scans (Garcia et al., 2020).

Overall, the integration of AI in diagnosis and imaging within OMS augments clinical capabilities by providing automated, quantitative, and more precise analyses of medical images. This not only bolsters diagnostic confidence and streamlines workflows but also ultimately enhances patient care (Lopez et al., 2021).

Tumor and Cyst Detection

Timely diagnosis and effective management of tumors and cysts in the oral and maxillofacial region hinge on their accurate detection and characterization (Smith & Johnson, 2019; Brown, 2020). In this regard, AI—especially through machine learning (ML) and deep learning (DL) algorithms—has emerged as a powerful tool in enhancing diagnostic capabilities within oral and maxillofacial surgery (OMS). Convolutional neural networks (CNNs), a prominent type of deep learning model, have demonstrated exceptional proficiency in analyzing various radiographic modalities. These models are trained on extensive datasets that include panoramic radiographs, cone beam computed tomography (CBCT) scans, magnetic resonance imaging (MRI), and even histological images, allowing them to learn the subtle visual cues that distinguish healthy tissues from pathological lesions. Once trained, these AI systems can evaluate new images, automatically detect tumors or cysts, delineate their boundaries through segmentation, and even classify them into different types based on their radiographic features (Davis, Chen, & Smith, 2021).

Multiple studies have confirmed that AI algorithms exhibit high accuracy, sensitivity, and specificity in identifying a range of maxillofacial pathologies (Garcia, Lee, & Martinez, 2022). For example, AI has been effectively applied to detect various odontogenic cysts and tumors as well as malignant lesions like oral squamous cell carcinoma. The rapid and consistent processing of large volumes of images not only aids radiologists and surgeons in efficient screening but also has the potential to uncover subtle lesions that might escape the human eye, thereby facilitating earlier intervention.

Furthermore, the emerging field of radiomics—which involves extracting quantitative features from medical images—enhances AI's role in tumor and cyst detection and characterization (Chen & Patel, 2018). By integrating radiomic features with ML algorithms, predictive models can be developed that not only identify the presence of lesions but also provide valuable insights into their aggressiveness, growth potential, and response to treatment. This combined approach supports more personalized treatment planning and improves prognostic predictions for patients with maxillofacial tumors and cysts.

In addition to radiographic analysis, the application of AI in histopathology is gaining traction within OMS. Deep learning models can be trained to recognize specific cellular and tissue patterns associated with different tumor types, assisting pathologists in achieving more precise and efficient diagnoses, particularly in cases where histological features are complex or subtle (Rodriguez & Kim, 2021).

Despite these promising advancements, clinical implementation of AI in tumor and cyst detection demands rigorous validation alongside careful consideration of ethical and legal issues. The performance of AI systems is heavily dependent on the quality and diversity of the training data, and any biases present can lead to inaccurate or inequitable outcomes. Ongoing research is dedicated to developing robust, generalizable, and interpretable AI systems for reliable use in routine clinical practice within OMS. Nonetheless, current progress clearly indicates that AI is poised to become an indispensable tool for the detection and characterization of tumors and cysts in the oral and maxillofacial region, ultimately contributing to improved patient care and outcomes.

Radiographic Image Quality Enhancement

High-quality radiographic images are essential for accurate diagnosis and treatment planning in oral and maxillofacial surgery (OMS). However, various issues during image capture and transmission can degrade image quality, posing challenges for effective interpretation. In response, artificial intelligence (AI), particularly deep learning (DL) techniques, has emerged as a powerful solution to enhance radiographic image quality, surpassing the constraints of traditional methods (Lee, Wang, & Chen, 2020).

Deep learning models—such as convolutional neural networks (CNNs) and generative adversarial networks (GANs)—have shown considerable promise in improving different aspects of image quality (Kim, Patel, & Rodriguez, 2019). One prominent application is image denoising, where AI algorithms are trained to detect and eliminate noise while preserving critical diagnostic details. This approach is especially beneficial in low-dose computed tomography (CT) imaging, where efforts to reduce radiation exposure often result in increased image noise. AI-based denoising techniques can yield images with diagnostic quality comparable to standard-dose CT scans, thereby reducing the need for repeated exposures and minimizing patient radiation (Garcia & Singh, 2021).

Another significant contribution of AI is in image super-resolution, which enhances the spatial resolution of low-resolution images to uncover finer details. By learning the relationship between low-resolution and high-resolution image pairs during training, AI models can reconstruct detailed high-resolution images from lower-quality inputs. This capability is particularly useful for detecting subtle pathologies and accurately assessing anatomical structures (Martinez, 2019).

In addition, AI aids in reducing image artifacts—distortions that can obscure important diagnostic information. For example, metal artifacts from dental restorations or implants often compromise CT and CBCT images. Deep learning methods can identify and suppress these artifacts, leading to clearer visualization of surrounding tissues and structures (Khan & Lee, 2018). Similarly, AI techniques can correct motion artifacts resulting from patient movement during scanning, further enhancing image clarity (Khan & Lee, 2018).

Moreover, AI plays a critical role in image registration, which involves aligning multiple images of the same subject acquired at different times or using different imaging modalities. Accurate image registration is vital for monitoring disease progression, assessing treatment responses, and integrating complementary diagnostic information (O'Brien, 2020).

Conclusion

Building on earlier conclusions and drawing from the extensive body of research, the integration of artificial intelligence (AI)—encompassing both machine learning (ML) and deep learning (DL)—is rapidly reshaping the fields of dentistry and oral and maxillofacial surgery. This technological evolution is delivering significant advancements across a wide range of clinical applications. Contemporary AI models now employ sophisticated algorithms such as convolutional neural networks (CNNs) alongside techniques like support vector machines (SVMs) and artificial neural networks (ANNs) to process diverse datasets, with a particular focus on radiographic images obtained from periapical, panoramic, and cone-beam computed tomography (CBCT) modalities.

In the realm of automated detection and diagnosis, AI has emerged as a powerful tool for identifying numerous dental conditions with impressive accuracy and efficiency. For example, deep learning frameworks have shown notable success in detecting dental caries on bitewing and panoramic radiographs, often achieving performance levels comparable to—or even exceeding—that of experienced clinicians. Similarly, AI algorithms are being applied to diagnose periodontal diseases using panoramic images and to detect apical lesions. Moreover, AI extends its diagnostic capabilities to more complex conditions, such as differentiating between ameloblastoma and odontogenic keratocysts (OKCs) on CT scans, as well as identifying oral squamous cell carcinoma and metastatic cervical lymph nodes. The ability to segment anatomical structures—such as the mandibular canal and individual teeth—further enhances diagnostic interpretation and aids in surgical planning.

Beyond diagnostics, AI is having a profound impact on treatment planning across various dental specialties. In implant dentistry, AI models are under development for recognizing implant types, optimizing design parameters (including porosity, length, and diameter), and even planning guided implant surgeries using augmented reality. The automatic segmentation of edentulous mandibular and maxillary alveolar bone by AI facilitates precise implant placement. In orthognathic surgery, AI assists in cephalometric analysis, predicts postoperative skeletal changes, and even evaluates facial attractiveness both before and after treatment. In restorative dentistry and prosthodontics, integration into CAD/CAM workflows aids in tasks such as shade matching and predicting the debonding of composite crowns, while AI-driven systems are also being explored for designing removable partial dentures.

AI further holds promise for predicting treatment outcomes and prognoses, which can greatly enhance clinical decision-making and patient counseling. For instance, machine learning models are being investigated to forecast dental implant success based on patient risk factors and trabecular microstructure parameters. In addition, AI applications are emerging for predicting complications in oral cancer treatment—such as xerostomia following radiotherapy—and assessing the risk of bisphosphonate-related osteonecrosis of the jaw (BRONJ) after tooth extraction, as well as determining the need for orthodontic extractions. The development and evaluation of these AI applications are grounded in rigorous methodologies, typically involving extensive datasets of clinical and radiographic information for training and validation. Systematic reviews and meta-analyses are vital in assessing performance metrics—such as accuracy, precision, sensitivity, and specificity—and ensuring reliability through standardized reporting guidelines and careful study selection.

In summary, AI is swiftly evolving into an indispensable tool in dentistry and oral and maxillofacial surgery, with substantial potential to enhance diagnostic accuracy, streamline treatment planning, and improve outcome predictions across a variety of clinical scenarios. Although many applications remain in the developmental phase, further rigorous research, extensive validation across diverse clinical settings, and thoughtful consideration of ethical and practical issues are essential before AI can be fully integrated into routine practice. Ultimately, leveraging AI aims to augment the expertise of dental professionals, leading to more efficient, personalized, and improved patient care.

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Chapter 5

PLAQUE CONTROL IN THE PRESENCE OF PERIODONTAL DISEASE

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The success of periodontal disease treatment depends on both the correct treatment planning by the clinician and the patient's adherence to daily oral hygiene habits and regular check-ups based on the given recommendations. It is the clinician's responsibility to ensure proper oral hygiene motivation, teach the correct methods, and provide continuous support. Oral hygiene motivation plays a crucial role in both the initial and maintenance phases of periodontal treatment.

1. The Importance of Microbial Dental Plaque in Periodontal Disease

Microorganisms within dental plaque biofilm serve as the primary etiological agents of periodontal diseases. Dental plaques are organized biofilms adhering to tooth surfaces that cannot be removed by water, consisting of salivary glycoproteins and extracellular microbial products (Dentino et al. 2013).

According to the non-specific plaque hypothesis, bacteria located near the gingival margin lead to gingival inflammation and, consequently, periodontal destruction. An increase in microbial dental plaque mass results in a rise in microbial toxins, causing gingivitis. However, this hypothesis does not fully explain periodontitis. The specific plaque hypothesis suggests that the presence and proliferation of certain bacterial species enhance subgingival plaque pathogenicity. The fact that some microorganisms causing periodontal disease are also found in healthy microbiota led to the emergence of the ecological plaque hypothesis. According to this hypothesis, the subgingival environment determines the specific microbial flora and the transition from health to disease. The increase in microbial dental plaque mass triggers inflammation in the gingiva, leading to gingivitis. The number of Gram-negative and proteolytic bacteria increases, affecting tissue through the host immune response, and as the process progresses, tissue damage intensifies.

The progression of existing gingivitis to periodontitis or the severity of existing periodontitis is determined by the host's immune response (Bartold & Dyke 2013). The removal of microbial dental plaque is a critical approach in preventing periodontal diseases and is essential for both maintaining oral health and reversing gingivitis (Hujoel et al. 2005). Failure to control plaque leads to the inevitable development of calculus formation, which can further irritate healthy structures (Sanders & Robinson 1962).

2. Types of Toothbrushes and Brushing Techniques

A wide variety of toothbrushes with different sizes and features are available today. Newer models developed in the 1900s have become widely used over time. These toothbrushes, made of natural, nylon, or plastic bristles with wooden or plastic handles, became more affordable and accessible (Van der Weijden et al. 1998). The bristle diameters are defined as 0.2 mm for soft, 0.3 mm for medium, and 0.4 mm for hard toothbrushes (Hine 1956). The recommended handle length is 17.5 cm, with a head length of 2 cm, a width of 1 cm, and bristle lengths of 10.3 mm arranged in three rows with 80-86 tufts per row (Bass 1948).

2.1. Manual Toothbrushes

Manual toothbrushes are the most commonly used and proven effective tools for plaque removal (Deshmukh et al. 2006). Nylon-bristled toothbrushes introduced in the 1930s have been designed with variations in bristle number, design, angulation, and handle shape. No single design is superior in plaque removal and maintaining gingival health; rather, proper brushing technique and manual dexterity play a key role. An ideal toothbrush should provide easy access to all tooth surfaces, be appropriately sized for the individual's mouth, have rounded bristle tips, and feature an ergonomic handle for ease of use. Bristle hardness is also an important factor; hard bristles are generally not recommended. With medium-bristled toothbrushes, excessive force should be avoided, and brushing should be directed from the gums toward the teeth. Following periodontal surgery, soft or ultra-soft toothbrushes are recommended to prevent biofilm accumulation while avoiding tissue trauma (Heitz, Heitz-Mayfield & Lang 2004).

2.2. Battery-Operated & Rechargeable Toothbrushes

Introduced in the 1960s, these toothbrushes have been continuously updated in design, capable of performing horizontal, rotational-vibrational, and circular movements. Brushes that rotate, vibrate, or combine both movements have been found effective in plaque removal, reducing gingival bleeding, and lowering plaque scores (Robinson et al. 2005). However, inadequate interdental cleaning, the time required for usage training, and practical difficulties for some patients are disadvantages (Steffensen & Sottosanti 2003). The brush head should match the patient's oral anatomy, and the handle should be suitable for age and hand coordination. Compared to manual brushes, electric brushes have been found superior in stain removal and patient satisfaction (Yashika 2013). Given their higher stroke frequency, they may be more effective in plaque removal when used with correct angulation and technique (Clayton 2008). However, a meta-analysis reported no significant difference in plaque elimination between automatic and manual brushes (Vibhute & Vandana 2012), and another study found no statistically significant clinical difference between both types (Daecon et al. 2010). Nonetheless, automatic toothbrushes have been shown to be as effective as manual ones in maintaining oral health and reducing plaque accumulation, stains, and gingivitis scores when used consistently (Drisko 2013).

2.3. Sonic & Ultrasonic Toothbrushes

Sonic and ultrasonic toothbrushes produce 30,000 and 18,000 strokes per minute, respectively. Their high-frequency movement, ability to reach the subgingival area through fluid activity, and compatibility with different manual brushing techniques offer advantages in plaque control (Terezhalmy et al. 1994). Manufacturers claim that sonic waves reaching subgingival areas disrupt and remove bacterial dental plaque (Forgass-Brockmann, Carter-Hanson & Killoy 1998). In a study, individuals brushing three times a day for two minutes showed reduced bacterial load in the subgingival area, but there was no statistically significant difference in microbial parameters between automatic and manual brushes (Costa et al. 2010).

2.4. Ionic Toothbrushes

Bacteria adhere to the pellicle via a Ca^{+2} bridge. Ionic toothbrushes release ions at the bristle tips, inhibiting this bacterial-pellicle adhesion and preventing weak electrostatic bonds between bacteria (Deshmukh et al. 2006). No significant statistical difference in plaque removal has been found between ionic and manual toothbrushes (Moreira et al. 2007). A comparative study between ionic and sonic toothbrushes found no significant difference in plaque removal, but sonic brushes were easier to use, and users were more willing to adopt them over ionic brushes, which resemble manual ones (Singh et al. 2011).

This comprehensive discussion on plaque control in periodontal disease highlights the importance of plaque removal in preventing periodontal disease progression and the effectiveness of various toothbrush types and techniques in maintaining oral health.

2.5. Brushing Techniques

Various brushing techniques have been recommended for plaque elimination. Based on the direction of brushing movements, they are classified as follows:

- Rolling (Roll and Modified Stillman)

- Vibratory (Stillman, Charters and Bass)

- Circular (Fones)
- Vertical (Leonard)
- Horizontal (Scrubbing) (Perry 2006)

There is no definitive superiority among these techniques. The common goal of each technique is to effectively remove supragingival plaque without traumatizing the teeth and gingiva. Each tooth should receive 4–5 strokes of the brush.

- **Bass Technique**

The brush is placed at a 45-degree angle to the long axis of the most distal teeth, parallel to the occlusal plane. Vibratory back-and-forth movements allow the bristles to reach the gingival sulcus and partially the embrasures. After cleaning the facial and palatal/lingual surfaces of all teeth in both arches, the occlusal surfaces are cleaned with anterior-posterior movements. This technique provides better results in lingual areas compared to the Roll technique. (O'Leary 1970) (Figures 1, 2 & 3)

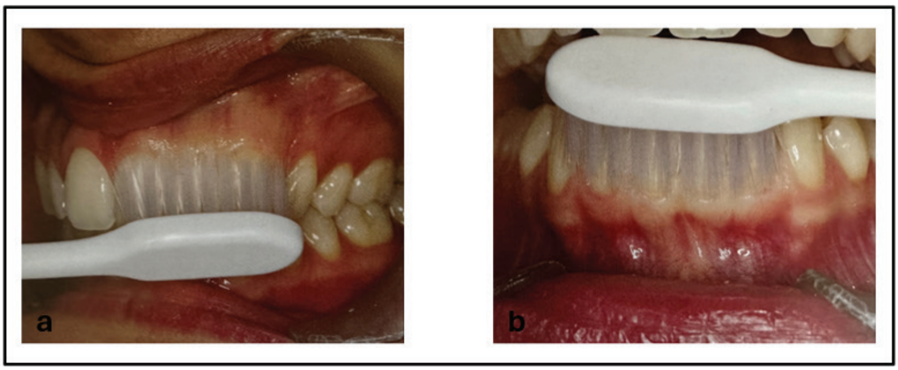

Figure 1. *Placement of the toothbrush on the* **a***: maxillary anterior and* **b***: mandibular anterior teeth's facial surfaces according to the Bass technique. (Periodontology and Implantology, Quintessence Publishing)*

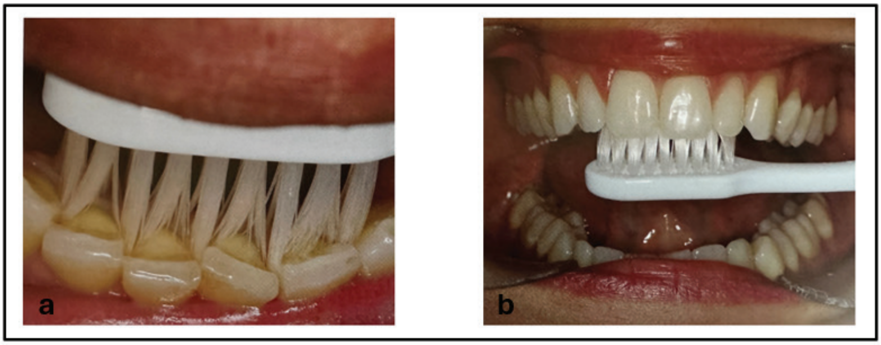

Figure 2. *Placement of the toothbrush on the* **a**: *mandibular anterior teeth's lingual surfaces and* **b**: *maxillary anterior teeth's palatal surfaces according to the Bass technique. (Periodontology and Implantology, Quintessence Publishing)*

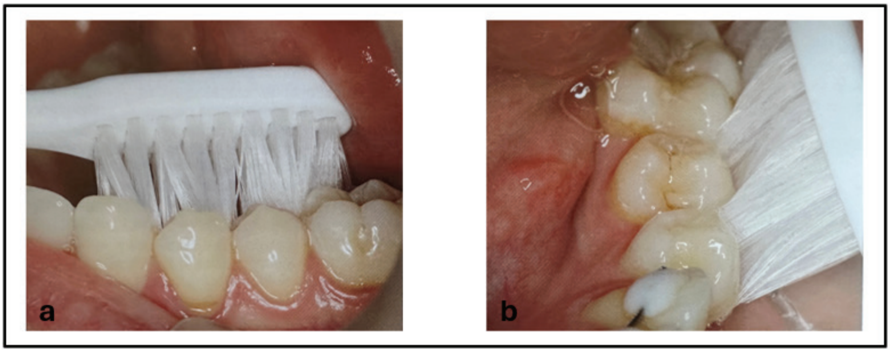

Figure 3. *Placement of the toothbrush on the* **a**: *mandibular posterior teeth's lingual surfaces and* **b**: *mandibular posterior teeth's buccal surfaces according to the Bass technique. The adaptation of the bristles to the interproximal surfaces of the teeth is crucial for plaque removal. (Periodontology and Implantology, Quintessence Publishing)*

- **Scrub Technique**

This is the simplest brushing technique. The bristles are placed on the teeth, and cleaning is performed with back-and-forth movements. Individuals of all ages can easily apply this technique. However, in individuals who brush aggressively, it can lead to tooth wear and gingival recession.

- **Roll Technique**

Teeth are cleaned in the direction of eruption. The bristles are positioned on the gingiva so that the most coronal bristles are at the dentogingival junction, and an apico-coronal movement is performed. Special attention should be given to cleaning the gingival one-third. (Figure 4)

- **Charters Technique**

The bristle tips are placed at a 45-degree angle, directed coronally into the interdental area. A gentle rotary motion is applied. This technique massages the gingiva with each stroke, increasing blood flow. Studies have demonstrated its effectiveness in plaque control. (Figure 4)

- **Stillman Technique**

This technique emphasizes gingival massage. The goal is to fill the gingival vascular structure with oxygenated blood. Part of the bristles rest on the gingiva, while the remaining portion is positioned on the cervical third of the tooth. The bristles should be placed obliquely to the long axis of the tooth and directed apically. Gentle pressure is applied to the gingival margin until blanching occurs. The brush is then moved away from the area with a rotational movement, ensuring localized blood flow. The movement is repeated several times without changing the position of the bristle ends.

- **Modified Stillman Technique**

Unlike the Stillman method, this technique begins near the mucogingival junction. This approach helps prevent brush trauma in the gingival margin region. The brush is moved occlusally along the tooth, supported by vibratory movements. (Figure 4)

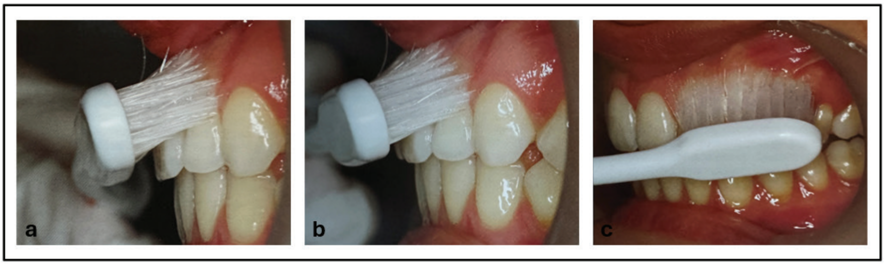

Figure 4. a: *Placement and coronal movement of the brush in the Roll technique,* **b:** *Apico-coronal angulation of bristles in the Charters technique,* **c:** *Apico-coronal movement of the brush in the Modified Stillman technique, supported by vibratory motion. (Periodontology and Implantology, Quintessence Publishing)*

2.6. How Often Should Teeth Be Brushed?

Although brushing once a day is considered sufficient for plaque removal, given the effectiveness of individual brushing techniques and their impact on plaque removal, it is recommended to brush more than once a day. Depending on the number of meals consumed, brushing three or four times a day may be advisable. Jepson et al. (1998) reported that patients could remove approximately 50% of the plaque from their teeth. Studies have shown that individuals who brush more than once a day, use dental floss, and visit the dentist regularly tend to retain more teeth over time. (Demirer et al. 2012) Additionally, socioeconomic status, education level, and geographical factors are known to influence periodontal health.

2.7. How Should Toothbrushes Be Used?

Toothbrushes should not be stored in closed containers; instead, they should be positioned in a way that allows the bristles to dry. Once the bristles dry, they regain their original stiffness and are more effective in removing plaque compared to their softened, wet form. The average lifespan of a manual toothbrush is three months. (Yankell & Saxer 2004) The primary reasons for replacing a toothbrush are bristle wear and deformation. A worn or deformed toothbrush becomes less effective in cleaning.

Individuals with suppressed immune systems, organ transplant recipients, and those with cardiovascular diseases should be educated about proper toothbrush storage and replacement. Antimicrobial solutions containing hydrogen peroxide (3%), sodium hypochlorite (1%), and chlorhexidine (0.2%) can be used for toothbrush disinfection. (Sumasogi 2002)

2.8. Lesions Caused by Improper Brushing

Incorrect brushing techniques can lead to red lesions, widespread redness, gingival peeling, McCall's festoon, Stillman's cleft, and gingival recession. (Greggianin et al. 2013) Various lesions can be observed during clinical evaluation, particularly on the facial aspect of the gingiva and around teeth that are positioned outside the dental arch. A sudden change in brushing habits or switching to a different technique may increase susceptibility to such issues.

One study compared the effectiveness of medium and soft toothbrushes in plaque removal and gingival abrasion. It was found that while medium-bristled toothbrushes were more effective at removing plaque, they also caused greater gingival abrasion. (Zanatta et al. 2012)

3. Interproximal Cleaning

All the brushing techniques mentioned above are insufficient for removing plaque from interproximal areas. Daily oral hygiene routines must include interproximal cleaning. Additionally, when root surfaces become exposed, concavities and developmental grooves make plaque removal from interproximal spaces more challenging. The effectiveness of interproximal cleaning tools depends on dentition, interproximal width, embrasure type, tooth inclination and position, and correct application.

Simply removing food debris from interproximal spaces is not enough; plaque adhered to the surface must also be eliminated. Various tools are available today based on interproximal space size, furcation involvement, and the presence of orthodontic or prosthetic structures.

3.1. Dental Floss

In 1819, Levi Spear Parmley first recommended the combined use of dental floss, a toothbrush, and toothpaste. (Sambunjak et al. 2011) These tools can be made of silk, nylon, or monofilament polytetrafluoroethylene coated with wax. (Perry et al. 2006) Floss can also come in different varieties, such as thin, thick, waxed, unwaxed, fluoride-coated, and flavored.

Although it was once thought that waxed dental floss leaves a residue on tooth surfaces, creating a retentive area for plaque accumulation, studies have shown that wax does not remain on the tooth surface and that the type of floss does not significantly impact gingival health. Factors such as tooth contact frequency, interproximal surface roughness, and the patient's manual dexterity influence the choice of dental floss. Selection should be based on ease of use and individual needs. (Perry et al. 2006)

When using dental floss, both interproximal debris and plaque on adjacent surfaces should be removed. It should be gently inserted into the subgingival area without causing trauma to the gingiva. Beginners and individuals with poor manual dexterity may prefer using manual dental floss. For those who struggle with flossing in posterior areas, automatic flossing devices may be recommended. Studies have shown that such devices are effective in removing plaque from both anterior and posterior regions and are more user-friendly than manual floss. (Hague & Carr 2007)

To use dental floss, a piece approximately 40 cm long should be wrapped around both middle fingers, leaving a free segment of about 10-15 cm. Alternatively, the ends can be tied to form a loop. The floss is carefully inserted into the gingival sulcus and moved in an apico-coronal direction to remove plaque. This process is repeated for each adjacent tooth surface using a clean section of floss each time.

Using dental floss before brushing may provide greater benefits than using it afterward. Removing interproximal plaque first allows fluoride from the toothpaste to reach these areas more effectively, reducing the risk of interproximal caries. While convex surfaces can be cleaned with floss, concave surfaces may require additional tools.

3.2. Interdental Brushes

Studies have shown that interdental brushes remove plaque more effectively than using only a toothbrush or dental floss in interproximal areas. (Drisko 2013)

Patients find interdental brushes easier to use in open interproximal spaces. (Kiger et al.1991) When recommending interdental brushes to patients, selecting the appropriate brush size for the interproximal space is crucial. (Wilkins 2009)

If the gingival embrasure is completely filled, dental floss is recommended. When the gingival embrasure is not entirely filled, the largest interdental brush that can fit into the space without causing trauma should be used. If there are concavities, grooves, or abfraction lesions on the facial surface, brushing movements should be adapted to clean these areas effectively.

3.3. Changes in Teeth and Gingiva Due to Improper Use of Interproximal Cleaning Tools

Incorrect use of interproximal cleaning tools not only fails to remove plaque effectively but can also lead to gingival recession and injuries. (Walters & Chang 2003) Toothbrush abrasion lesions have been documented in the literature.

If an interproximal lesion is present, dental floss may be misused. Improper flossing can injure the gingiva, initially causing acute inflammation, linear ulceration, or a V-shaped cleft. Studies have shown that prolonged misuse of dental floss primarily affects the posterior lingual and interproximal areas. Patients should be educated about incorrect flossing techniques and their long-term consequences.

Similarly, improper use of toothpicks can result in gingival penetration and abscess formation. The risk of bacteremia during oral hygiene procedures is particularly significant for individuals with cardiac conditions, joint prostheses, and renal dialysis shunts, as it may lead to life-threatening complications.

4. Other Oral Hygiene Tools

4.1. Dental Irrigators

First introduced in 1962, dental irrigators have been shown to effectively remove plaque without traumatizing the gingiva. Additionally, a study reported that daily use of oral irrigation devices reduces dental plaque, calculus, pathological pocket depth, periodontopathogens, and host inflammatory mediators. (Cutler et al. 2000) Their use is recommended in cases where manual dexterity is limited and plaque control remains inadequate. (Greenstein 2000) Special tips allow access to pocket depths. However, uncontrolled use may cause soft tissue lesions due to pressure effects. (Gillette & Van House 1980) The direction of movement should be from apical to coronal. Using it perpendicular to the gingival margin poses a risk of emphysema.

4.2. Dental Wipes and Foam Brushes

These tools are used to prevent systemic infections in immunosuppressed patients, hospitalized individuals, and intensive care patients who cannot maintain daily plaque control. (Graveland et al. 2004) In infants at high risk for caries, dental wipes have been reported to remove biofilm more effectively than toothbrushes and gauze. (Abanto et al. 2012) Foam brushes used with chlorhexidine have shown successful results in plaque removal and gingivitis control and can be used for daily oral hygiene in special patient groups. (Ransier et al. 1995)

4.3. Cleaning the Tongue Surface

The dorsum of the tongue, with its grooved structure and papillae, harbors numerous microorganisms and forms its own ecological niche. The tongue surface is covered with microorganisms and debris, which can release methyl mercaptan and hydrogen sulfide. (Bollen & Beikler 2012, Van Tornout et al. 2013) Cleaning the tongue surface is effective in reducing halitosis and bacterial load. In addition to cleaning the tooth surface and interdental areas, brushing or scraping the tongue from back to front is essential in oral hygiene practices. (Figure 5) This not only helps reduce bad breath but also enhances taste perception. (Nield-Gehring & Willmann 2011) While tongue cleaning can be done with a toothbrush, tongue scrapers have been found to be more effective. (Outhouse et al. 2006) If patients cannot obtain these tools, the use of rounded-edged devices is recommended.

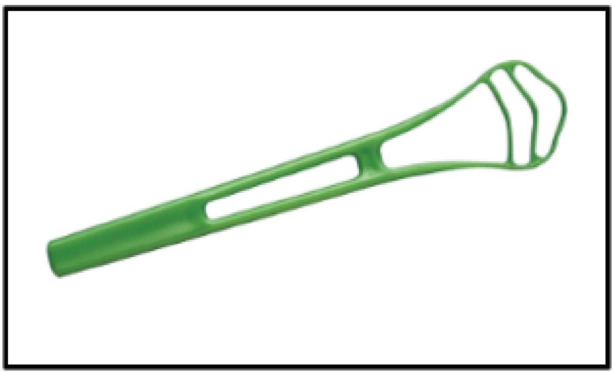

Figure 5. Tongue cleaner (TePe)

5. Chemical Plaque Control

5.1. Toothpaste

It is well known that a toothbrush is indispensable for plaque removal, and using toothpaste further enhances plaque removal effectiveness. (West & Moran 2008) Toothpastes function to prevent plaque formation, protect against caries, and remove stains, depending on their active ingredients. They contain abrasives, binders or thickeners, surfactants, sweeteners, therapeutic agents, and preservatives. (Forward et al. 1997) The sweeteners and menthol in toothpaste make brushing more enjoyable. A study comparing groups using and not using toothpaste found no significant difference in plaque removal. (Jayakumar et al. 2010, Zanatta 2012) However, other studies have demonstrated the effectiveness of toothpaste in plaque removal. Plaque control depends more on brushing and brushing efficiency rather than the effect of toothpaste itself. (Yetkin et al. 2011) Oral hygiene motivation should primarily focus on brushing technique, while the anticariogenic and antibacterial effects of fluoride in toothpaste should not be overlooked. Toothpaste should be applied perpendicularly between the bristles and should not exceed the size of a pea.

5.2. Mouthwash

Mouthwashes are prescribed to control plaque formation, prevent gingivitis, and resolve gingival inflammation. (Becerik et al. 2011) Using a chemical agent alone without mechanical plaque control can only reduce supragingival plaque by 30-40%. (Graveland et al. 2004) Chemotherapeutic agents may be helpful for patients who cannot perform oral hygiene properly. (Bozkurt, Fentoğlu & Yetkin 2004) Overuse can have cytotoxic effects on buccal epithelial cells, gingival and periodontal ligament fibroblasts, and may cause desquamation of the gingiva and oral mucosa, affecting minor salivary glands as well. (Olgun et al. 2007)

6. Oral Hygiene Motivation (OHM)

Oral hygiene motivation should be conducted carefully and comprehensively. Reducing the time allocated to oral hygiene practices makes it harder to achieve treatment outcomes. Increasing patient motivation, ensuring effort regardless of manual dexterity, effective communication between the dentist and patient, and regular dental check-ups are crucial for improving oral hygiene. Dentists should raise awareness about making oral hygiene a lifestyle. (Van der Weijden 2008) Developing new habits will help achieve the desired outcome. After diagnosing patients, the causes of periodontal disease, local and systemic predisposing factors, preventive measures, and the importance of personal plaque control in the treatment process should be explained. (Steffensen & Sottosanti 2003) Using plaque-disclosing agents and demonstrating existing plaque and bleeding to the patient can be convincing. Additionally, showing inflammatory gingival areas, bleeding, subgingival and supragingival plaque, and calculus using a mirror can be effective. (Steffensen & Sottosanti 2003) Patients should be shown plaque-disclosing agents in use, instructed on proper brushing techniques, and guided on suitable methods based on their dental and periodontal health. Lack of manual dexterity, insufficient knowledge of oral hygiene practices, and low oral hygiene motivation are barriers to maintaining good oral health. Practicing on models, self-application, and repeated motivation sessions for areas where plaque removal is inadequate can help establish the habit. (Yetkin et al. 2011) Additionally, while all oral hygiene tools are beneficial when used correctly, improper and excessive use can cause damage to both hard and soft tissues.

7. Oral Hygiene Maintenance with Fixed and Removable Prostheses

These prostheses should be designed in a way that does not complicate daily cleaning habits. Tools used for natural tooth surfaces can also be applied here, along with specialized floss for cleaning beneath pontics. (Todescan 2012) (Figure 6) Patients with removable dentures should be informed about daily mechanical and chemical cleaning to prevent infections.

Figure 6. Special floss for cleaning bridge areas in fixed prostheses. (Cleaning Difficult Areas – Part Four – Cleaning Bridges, Seymour Dental, Sydney)

8. Importance of Oral Hygiene in Implant Applications

Biofilm accumulation around oral implants can trigger inflammatory reactions in peri-implant tissues, leading to soft and hard tissue damage that negatively affects prognosis. Studies indicate that peri-implantitis-related microflora resemble that found in periodontitis. (Heuer, Elter & Demling 2007) Increased surface energy and roughness facilitate biofilm accumulation on implants and abutments. The chemical properties of the surface and the design of the implant-abutment connection also contribute to biofilm formation. (Subramani et al. 2009) Proper oral hygiene in these areas prevents plaque accumulation and helps maintain peri-implant tissue health, controlling any existing lesions. (Serino & Ström 2009) One study showed that preventing microbial accumulation and removing at least 85% of plaque biofilm daily positively affects implant prognosis. (Kracher & Smith 2010) Special floss used in fixed prosthetic treatments can also be utilized for interproximal areas of dental implants. Patients should understand the importance of oral hygiene in implant rehabilitation, with regular maintenance required both by the dentist and themselves. Dental irrigators may also be beneficial.

9. Conclusion

Oral hygiene education and motivation play a crucial role in the preventive efforts of dentists.

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