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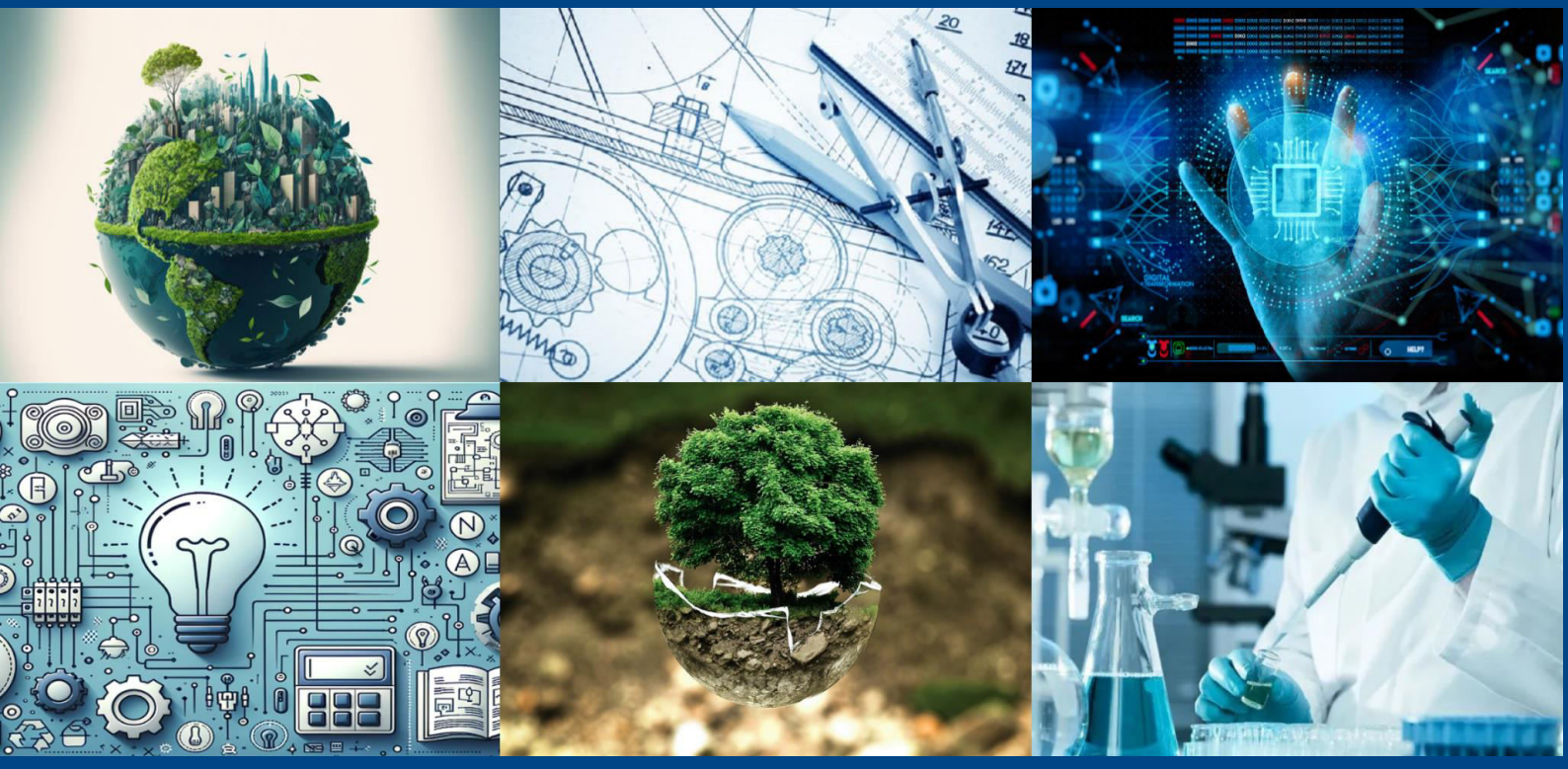

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'Smile Arc' in Prosthodontics- A Narrative Review

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ABSTRACT: A crucial aesthetic factor in dentistry, especially in orthodontics, prosthodontics, and cosmetic dentistry, is the Smile Arc, which is the curve of the maxillary front teeth's incisal margins in relation to the curvature of the lower lip when smiling. It has a significant impact on patient happiness and face aesthetics by helping to create smiles that are harmonic and aesthetically pleasing. The Smile Arc is used to guide orthodontic alignment, crowns, veneers, dentures, implants, and smile makeovers. It is divided into three types: consonant (ideal, paralleling the lip), flat, and reverse. Through accurate visualisation, customisation, and production, digital workflows that make use of Digital Smile Design (DSD), intraoral scanning, and CAD/CAM improve Smile Arc planning. Modern dentistry relies heavily on the Smile Arc, which connects function and beauty. Although there are still practical and anatomical constraints, its incorporation into digital processes has enhanced treatment outcomes. Smile Arc's role in patient-centered dental treatment will be strengthened by future developments in AI, AR/VR, and personalised aesthetics.

KEYWORDS: Smile Arc, Aesthetic Dentistry, Prosthodontics, Digital Smile Design, Smile Aesthetics.

I. INTRODUCTION

In dentistry, the Smile Arc is the curve created by the canines, lateral incisors, and central incisors of the maxillary anterior teeth in relation to the lower lip curvature when a person smiles, giving them a youthful, natural, and attractive smile. The phrase "Smile Arc" was formalised and made popular by renowned orthodontist Dr. David M. Sarver. Smile Curve, Incisal Edge Contour, Smile Line, and Aesthetic Line are some other names for Smile Arc. [1]
In dental aesthetics, this idea has become more well-known, particularly in the wake of the "new aesthetic paradigm," which highlights the significance of smile harmony in treatment planning. Based on the relationship between the incisal margins of the upper teeth and the curve of the lower lip, there are three primary types of smile arcs, however there are some variations.: [Table-1]

Type	Description	Aesthetic Appeal	Prevalence
Consonant	Incisal edges parallel the lower lip's curve	Youthful, attractive	Approx 60%
Flat	Incisal edges form a straight line	Less dynamic, less youthful	34%
Reverse	Incisal edges curve downward, opposite to lip curve	Aged, unnatural appearance	5%

Table-1: Types of Smile arcs.

Indications of Smile Arc [1-5]
In clinical situations where smile aesthetics are the main issue, the Smile Arc is recommended. It directs the design and implementation of treatments to improve a patient's smile's harmony and beauty. Important signs consist of:

Prosthodontic Restorations: directs the creation or maintenance of a consonant Smile Arc in the design of crowns, veneers, bridges, dentures, and implant-supported prostheses. recommended when replacing teeth in full or partial dentures, or when anterior teeth are damaged, broken, or absent.

Cosmetic Dentistry and Smile Makeovers: used to design complete cosmetic restorations that incorporate gingival contouring, veneers, crowns, and implants. recommended for patients who are unhappy with the shape, alignment, or gingival display of their teeth and want to improve the aesthetics of their smile.

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Implant Dentistry: makes sure the Smile Arc and implant-supported restorations in the anterior maxilla line up for the best possible appearance. recommended for full-arch implant prostheses (like All-on-4) or single-tooth replacements.

Orthodontic Treatment Planning: used to plan the movement of teeth to create a consonant Smile Arc, in which the incisal edges match the curvature of the lower lip.

Periodontal and Gingival Aesthetics: directs crown lengthening or gingival sculpting operations to maximise gingival presentation and assist the Smile Arc. recommended when there is an uneven gingival margin or excessive gingival display, also known as a "gummy smile."

Digital Smile Design (DSD): Before treatment, the intended Smile Arc is visualised and communicated using digital planning. recommended in multidisciplinary instances involving cosmetic dentistry, prosthodontics, and orthodontics.

Facial Aesthetics and Modeling: taken into consideration in non-clinical settings where grin aesthetics affect professional image, such as modelling and the media. recommended for anyone looking to improve their smiles for personal or professional purposes.

Limitations of Smile Arc [3-6]

Although the Smile Arc is a useful aesthetic guideline, anatomical, clinical, and patient-specific considerations limit its applicability. These limitations may make it more difficult to create the perfect consonant Smile Arc or may necessitate making adjustments to the treatment approach.

Anatomical Constraints: Achieving the ideal consonant Smile Arc may be hampered by differences in lip shape, length, or dynamics. Even with optimal tooth location, patients with a flat or uneven lower lip curve might not naturally support a consonant Smile Arc. The perceived arc can also be changed by lips that are short or hypermobile.

Skeletal and Dental Limitations: Smile Arc optimisation may be limited by underlying skeletal abnormalities or dental malposition. The ability to align the incisal margins with the curvature of the lower lip without orthognathic surgery or extensive orthodontics may be limited by severe Class II or III skeletal patterns, vertical maxillary excess, or notable tooth size disparities.

Tooth Morphology and Wear: Smile Arc restoration may be hampered by the size, shape, or wear patterns of the natural tooth. The optimum curve may be disturbed by small lateral incisors, worn incisal edges, or disproportionate teeth, necessitating restorative procedures (like as veneers), which may not be practical for every patient. To restore a consonant Smile Arc, a patient with severe incisal wear might require substantial restorations, which could be prohibitively expensive.

Patient Preferences and Cultural Variations: The ideal consonant Smile Arc may not align with personal or cultural aesthetic preferences. In contrast to the consonant ideal, some patients or cultures want a flatter or less noticeable Smile Arc for a more subdued or distinctive appearance. For a more understated look, a patient could prefer a straight Smile Line over a curved Smile Arc.

Aging and Soft Tissue Changes: Over time, the Smile Arc's appearance may change because to age-related changes in muscle tone, gingival tissues, or lip position. It might be difficult to maintain a consonant arc without constant interventions as patients age due to lip drooping or decreased flexibility, which flattens the Smile Arc. When lip sagging causes an older patient with a previously consonant Smile Arc to acquire a reverse arc, restorative or surgical changes may be necessary.

Treatment Complexity and Cost: Complex, multidisciplinary, or expensive procedures could be necessary to get the optimal Smile Arc. For certain people, maximising the Smile Arc may require time-consuming, costly, or inaccessible procedures like orthodontics, implants, or periodontal surgery. A patient may choose a less optimal prosthetic device because of the cost if they require orthognathic surgery to rectify a skeletal discrepancy for Smile Arc enhancement.

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Dynamic Smile Variability:
Treatment planning is made more difficult by the Smile Arc's appearance, which differs between static (posed) and dynamic (spontaneous) grins. It can be difficult to attain universal aesthetic success when a consonant grin Arc in a posed grin seems flat or reversed in dynamic expressions because of lip movement or muscle dynamics. The Smile Arc of a patient requires design concessions because it appears perfect in photos but less harmonic when spoken.

Prosthodontic Material and Fabrication Constraints: Exact Smile Arc replication may be limited by material characteristics or laboratory constraints. In prosthodontics, the ability of the technician or the characteristics of the material (such as acrylic or porcelain) may limit the ability to achieve the precise incisal edge curvature, particularly in complex situations like full-arch dentures. Standardised tooth moulds may not precisely match the patient's lip curve, resulting in a somewhat flatter Smile Arc for a complete denture.

Future Directions [7]
Advances in artificial intelligence (AI), augmented reality (AR), and virtual reality (VR) are anticipated to significantly improve Smile Arc planning as digital dentistry develops, increasing patient engagement and personalisation. The Smile Arc's function in attaining patient-centered results will continue to be shaped by the integration of these technologies, as indicated by current developments in aesthetic dentistry. With three main types—consonant, flat, and reverse—as well as an occasional asymmetric variation, the Smile Arc is an essential cosmetic measure in dentistry. Its main features emphasise its aesthetic value, the disparities in gender and age, and its crucial function in dental procedures that are aided by computerised workflows. Despite several difficulties, its incorporation into contemporary practice emphasises how crucial it is to improving patient happiness and smiling harmony.

The components of Smile Arc [1,2,8,9]
A key idea in dentistry, the grin Arc describes the connection between the lower lip's curve during a grin and the maxillary anterior tooth's (upper front teeth) curvature. It is a crucial aesthetic criterion for assessing and creating harmonious, appealing grins.

Maxillary Anterior Teeth (Upper Incisors and Canines):
The visible curve of the grin arc is formed by the incisal margins of the upper front teeth, which include the canines, lateral incisors, and central incisors. Positioning: The shape of the arc is determined by the vertical and horizontal positioning of these teeth. The incisal borders should follow the lower lip's curvature for the perfect smile arc.

Inclination: The arc's alignment with the lip line is influenced by the teeth's labial (outward) or lingual (inward) tilt. While uneven or misaligned teeth can produce a flat or reverse grin arc, which lessens visual appeal, properly aligned teeth improve smile aesthetics.

Lower Lip Curvature:
In a natural grin, the curvature of the smile arc is referenced by the lower lip. Each person has a different form, which can range from a soft curvature to a more noticeable cupid's bow. When the incisal margins of the upper teeth line up with the curvature of the lower lip, the grin arc is ideal (consonant). The smile may not be as harmonious if there is a mismatch (such as divergent or flat curvature). To establish a balanced smile, orthodontic and restorative adjustments are guided by the contour of the lower lip.

Gingival (Gum) Display:
The aesthetics of the smile arc are influenced by the quantity of gum tissue that is visible above the top teeth when smiling. While a tiny bit of gum (1–2 mm) is frequently regarded as aesthetically pleasing, too much gingival display (also known as a "gummy smile") or too little display can throw off the harmony of the smile arc. In order to maximise gingival contours for the perfect smile arc, orthodontists may employ periodontal operations or modify tooth location.

Smile Width:
The number of teeth visible in a smile (e.g., up to the premolars or molars) affects the perceived fullness of the smile arc.

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Buccal Corridor: The buccal corridor—the area between the lateral teeth and the corners of the mouth—affects the smile's visual harmony. The prominence of the smile arc is increased by narrow buccal corridors. While a narrow smile may lessen the impact of the smile arc, a wider smile with more visible teeth can highlight it.

Tooth Proportions and Shape:
The appearance of the grin arc is influenced by the size, shape, and proportions of the anterior teeth (such as the width-to-length ratio). Perfect The central incisors usually have a little curve because they are slightly longer than the lateral incisors. The arc may be disturbed by damaged or uneven teeth. Refinement of tooth proportions is often the goal of restorative operations like veneers or bonding in order to improve the smile arc.

Facial and Lip Dynamics:
The movement and shape of the lips during smiling, as well as facial symmetry, influence how the smile arc is perceived.

Dynamic Smile: To make sure the smile arc maintains its visual appeal when moving, it is assessed under dynamic circumstances (such as when speaking or laughing). In order to make sure that the smile arc enhances the patient's facial characteristics in a variety of emotions, orthodontic treatment takes lip dynamics into account. To guarantee accurate treatment planning, the smile arc is evaluated utilising diagnostic models, digital smile design software, or clinical photography. Clinicians adjust therapies to meet patient expectations because cultural and personal preferences might affect how people see the optimal smile arc.

Role of Smile Arc in Prosthodontic Treatments [1,4,5,7]

1.Complete Dentures:
The Smile Arc directs the placement of anterior teeth during the production of complete dentures in order to replicate the natural dentition and improve facial appearance. In order to maintain a consonant Smile Arc when smiling, the incisal margins of the maxillary front teeth are positioned to follow the curvature of the lower lip. A well-designed Smile Arc enhances the denture's look, patient satisfaction, and perceived youth.
Clinical Aspects to Take into Account: A flat or reverse arc is avoided by supporting the Smile Arc with adjustments to the occlusal plane and vertical dimension of occlusion (VDO). Before the denture is finalised, the Smile Arc is assessed using wax try-ins and digital smile design tools. The buccal corridor and lip support are optimised to increase the prominence of the Smile Arc.
In order to prevent a boring or ageing appearance, prosthodontists choose tooth moulds and position teeth in edentulous patients to form a consonant Smile Arc. The Smile Arc can be flattened by improper tooth alignment or high VDO, and a reverse arc can be produced by insufficient lip support.

2.Removable Partial Dentures (RPDs):
When replacing anterior teeth in RPDs, the Smile Arc is taken into account to maintain continuity with the natural teeth that are already present. The prosthetic teeth blend in perfectly with the patient's smile by being positioned to preserve or restore a consonant Smile Arc.
Clinical Aspects to Take into Account:
In order to mimic the curvature of nearby natural teeth, the Smile Arc is assessed during the design stage. The Smile Arc's visibility is maintained by using precise attachments or aesthetic clasps. The prosthetic teeth in a Kennedy Class IV RPD (anterior edentulous area) are shaped to follow the curve of the lower lip, maintaining the appearance of the smile. The Smile Arc may be disturbed by misaligned or discoloured teeth, necessitating careful shade selection and try-ins.

3.Fixed Dental Prostheses (Crowns, Bridges, and Veneers):
A crucial factor in creating veneers, crowns, and bridges that look natural is the Smile Arc. In order to improve smile harmony, the incisal borders of front restorations are positioned and sculpted to produce or preserve a consonant Smile Arc. To maximise the Smile Arc, veneers and crowns are made to fit the length, inclination, and curvature of the tooth.
Clinical Aspects to Take into Account:
Prior to production, the Smile Arc is frequently planned and visualised using digital smile design (DSD) software. The Smile Arc is complemented by adjusting the gingival margin and tooth proportions (such as the width-to-length ratio). Before the Smile Arc is permanently placed, patients and physicians can evaluate it using temporary restorations.

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Porcelain veneers are intended to restore a consonant Smile Arc in patients with worn anterior teeth by lengthening the central incisors and gently curving them. A flat or reverse Smile Arc can result from overcontoured restorations or incorrect incisal edge placement, which compromises appearance.

4.Implant-Supported Prostheses:
In order to guarantee that the prosthetic teeth match the curvature of the lower lip, the Smile Arc is essential in implant-supported restorations (such as single crowns, bridges, or full-arch prostheses). The abutment design and implant placement are intended to support the intended Smile Arc, especially in the anterior maxilla.

Clinical Aspects to Take into Account:
The Smile Arc is supported by the emerging profile and soft tissue contours surrounding implants, which are designed to resemble the natural gingival architecture. Before the final prosthesis is fabricated, the Smile Arc is refined using custom abutments and temporary restorations. The Smile Arc is intended to avoid a monotonous appearance in full-arch implant prosthesis (like the All-on-4) by striking a balance between appearance and functionality. An implant crown is shaped to follow the incisal curve of the neighbouring teeth in order to preserve the Smile Arc for a patient who has lost a maxillary central incisor. Smile Arc rehabilitation may be complicated by bone loss or incorrect implant angulation, necessitating angled abutments or bone grafting.

5.Smile Makeover and Aesthetic Rehabilitation:
The Smile Arc is the main goal of extensive smile makeovers in order to produce a Hollywood-style smile. An ideal consonant Smile Arc that is customised to the patient's facial features is created using a combination of veneers, crowns, implants, and gingival contouring.

Clinical Aspects to Take into Account:
To guarantee adaptability, the Smile Arc is assessed under both static (posed) and dynamic (speaking, laughing) circumstances. The intended Smile Arc curvature (subtle vs. dramatic, for example) is determined by patient input and cultural preferences. In order to improve gingival presentation and produce a consonant Smile Arc, a patient desiring a smile makeover is treated with veneers and laser gingivectomy. It takes careful communication and mock-ups to strike a balance between clinical viability and patient expectations.

Role of Smile Arc in Digital Workflow Protocols [4,7,9,10]
The Smile Arc guides the aesthetic design of orthodontic treatments, smile makeovers, and dental restorations, making it a fundamental component of digital workflows. Clinicians may now analyse, model, and modify the Smile Arc with previously unheard-of precision thanks to digital tools, guaranteeing that it blends in with the patient's facial features. Among the principal roles are:

Visualization and Planning:
Before starting treatment, doctors can see the optimal tooth-lip relationship thanks to digital procedures that map the Smile Arc using software. To design tooth placement and restoration shapes, tools such as Digital Smile Design (DSD) superimpose the Smile Arc onto 3D models or photos of the face.

Customization:
The Smile Arc is tailored to the patient's unique lip dynamics, facial proportions, and aesthetic preferences using digital simulations. Adjustments to tooth length, inclination, and curvature are made virtually to achieve a consonant Smile Arc.

Patient Communication:
Digital mock-ups and visualizations of the Smile Arc help patients understand proposed outcomes, improving satisfaction and informed consent. Virtual try-ins allow patients to preview their Smile Arc in static and dynamic conditions.

Precision in Execution:
Digital workflows integrate with CAD/CAM systems and 3D printing to fabricate restorations (e.g., veneers, crowns, dentures) or orthodontic aligners that precisely replicate the planned Smile Arc. Guided implant placement and restorative designs ensure the Smile Arc aligns with the digital plan.

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II. INTERDISCIPLINARY COLLABORATION

Digital platforms facilitate communication among orthodontists, prosthodontists, periodontists, and dental technicians to coordinate Smile Arc optimization across treatments.

Digital Workflow Protocol for Smile Arc Optimization

The digital workflow protocol for incorporating the Smile Arc involves a systematic approach, combining diagnostic, design, and fabrication steps. Below is a detailed outline of the process:

1. Data Acquisition

Intraoral Scanning: Intraoral scanners (e.g., iTero, Trios) capture 3D models of the teeth and soft tissues, providing accurate data for Smile Arc analysis. Eliminates the need for physical impressions, improves patient comfort, and ensures high-resolution data.

Facial Photography and Videography: High-resolution photographs (frontal, lateral, and 45-degree views) and videos capture the smile in static (posed) and dynamic (speaking, laughing) conditions. To analyze the lower lip's curvature, gingival display, and smile width in relation to the Smile Arc.

Facial Scanning: 3D facial scanners (e.g., Bellus3D) map facial contours, enabling integration of the Smile Arc with overall facial aesthetics.

Cone Beam Computed Tomography (CBCT) (if needed):

Used in complex cases (e.g., implants or orthognathic surgery) to assess bone structure and tooth roots affecting Smile Arc planning.

2. Digital Smile Design (DSD)

Software Analysis: DSD software (e.g., DSD App, Smile Designer Pro) or other platforms (e.g., Exocad, 3Shape) are used to superimpose the Smile Arc onto facial images or 3D models. Key measurements include the curvature of the incisal edges, tooth proportions (width-to-length ratio), and gingival margin alignment relative to the lower lip.

Smile Arc Simulation: The ideal consonant Smile Arc is designed by adjusting tooth positions, lengths, and inclinations virtually. Templates or reference lines (e.g., lip line, occlusal plane) guide the design to ensure harmony.

Patient Feedback: Virtual mock-ups are presented to the patient via screen or printed models, allowing them to visualize the proposed Smile Arc and provide input.

3. Treatment Planning

Orthodontic Planning: Software like ClinCheck (Invisalign) or OrthoCAD plans tooth movements to achieve the desired Smile Arc. Extruding central incisors to correct a flat Smile Arc or adjusting torque to align with the lip curve.

Prosthodontic Planning: CAD software designs restorations (e.g., veneers, crowns, dentures) with incisal edges contoured to match the planned Smile Arc. Designing veneers to lengthen incisors for a consonant arc in a smile makeover.

Implant Planning: Guided surgery software (e.g., Blue Sky Plan) plans implant placement to support restorations that align with the Smile Arc. Angling implants to ensure the crown's incisal edge follows the lip curvature.

Periodontal Planning: Digital tools plan gingival contouring or crown lengthening to optimize gingival display and enhance the Smile Arc.

4. Fabrication and Execution

CAD/CAM Fabrication: Restorations (e.g., veneers, crowns, bridges) are milled using CAD/CAM systems (e.g., CEREC, Roland) based on the digital Smile Arc design. Dentures or implant prostheses are 3D-printed or milled with precise incisal edge contours.

Orthodontic Aligners: Clear aligners (e.g., Invisalign) are 3D-printed to move teeth according to the Smile Arc plan.

Guided Surgery: Surgical guides for implants ensure placement aligns with the planned Smile Arc.

Provisional Restorations: Temporary restorations or 3D-printed mock-ups allow clinicians to verify the Smile Arc before final fabrication.

5. Verification and Follow-Up

Intraoral Verification: Post-treatment intraoral scans and photographs confirm the achieved Smile Arc matches the digital plan.

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Dynamic Assessment: Videos assess the Smile Arc in dynamic conditions to ensure aesthetic harmony during speech and laughter.
Patient Satisfaction: Patients review the final Smile Arc and provide feedback, with minor adjustments (e.g., polishing, bonding) made if needed.
Long-Term Monitoring: Digital records are stored for future reference, allowing clinicians to monitor Smile Arc stability over time (e.g., due to aging or wear). Benefits of Digital Workflow for Smile Arc
Precision: Intraoral scanners and CAD/CAM ensure accurate replication of the planned Smile Arc. Virtual simulations reduce trial-and-error, improving treatment outcomes. Visualizations enhance patient understanding and satisfaction. Streamlined workflows reduce chair time and laboratory turnaround.
Interdisciplinary Integration: Digital platforms facilitate collaboration across specialties.

III. CONCLUSION

A key component of prosthodontics and aesthetic dentistry is the Smile Arc, which is the curve of the maxillary anterior teeth's incisal edges in relation to the curvature of the lower lip when smiling. It has a major impact on patient satisfaction and face aesthetics and is a crucial factor in creating smiles that are harmonic, natural, and aesthetically pleasing. The Smile Arc serves as a guide for the design and implementation of various dental procedures, including complete dentures, removable partial dentures, fixed prostheses (crowns, bridges, veneers), restorations supported by implants, and total smile makeovers. By improving accuracy, predictability, and patient communication, its incorporation into digital workflow protocols—using technologies like CAD/CAM, intraoral scanning, and Digital Smile Design (DSD)—has completely changed treatment planning.

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