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Review Paper: A Comprehensive Classification of Guides in Dentistry: A Literature Review

Maryam Jahangiri[1], **Sayed Shojaedin Shayegh**[1*]

1. Department of Prosthodontics, Faculty of Dentistry, Shahed University, Tehran, Iran

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ABSTRACT

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The utilization of guides in dentistry presents one of the most precise and conservative approaches to executing dental procedures. A variety of guide types have been designed and introduced. This study categorizes the different types of guides while introducing each and exploring their unique characteristics. All articles pertaining to guides were collected and analyzed by searching through PubMed and ISI Web of Science databases up until 2024. Subsequently, the content was categorized into the following topics: implant surgical guides, surgical guides for esthetic crown lengthening, fiber post removal guides, endodontic guides, veneer cementation guides, and tooth reduction guides. Each category was examined in detail. Based on the findings of this review study, dental guides can be classified into: implant surgical guides, surgical guides for esthetic crown lengthening, fiber post removal guides, endodontic guides, veneer cementation guides, and tooth reduction guides. Implant surgical guides themselves can be further categorized, such as mesiodistal guides, guides specific to implant systems, and guides for All-on-4 surgeries. Additionally, innovative designs of implant surgical guides have been introduced, such as guides for sinus lift surgery and guides for guided block injection. The fabrication of these guides is now commonly performed digitally, offering high precision and speed.

*** Corresponding Authors:**
Sayed Shojaedin Shayegh
***Address:** Department of Prosthodontics, Faculty of Dentistry, Shahed University, Tehran, Iran*
***Tel:** +989331503692*
***E-mail:** shayeghshahed2024@gmail.com*

1. Introduction

Tooth loss, a prevalent dental issue arising from various causes such as caries, periodontal disease, and trauma, can significantly impact an individual's quality of life (1, 2). Beyond functional implications, it can lead to aesthetic concerns and reduced self-esteem, particularly when affecting anterior teeth (3). While multiple treatment options exist, including fixed and removable prostheses, dental implants have emerged as a popular choice due to their long-term success and natural (4).

The success of dental implant treatment is contingent upon accurate implant placement (5). Precise positioning ensures optimal bone-implant integration, minimizes damage to adjacent anatomical structures, and maximizes the longevity of the restoration. However, achieving this precision can be challenging, especially in complex cases or when dealing with limited bone volume (6).

Aesthetic smile design has become a crucial aspect of modern dentistry (7). In cases of gummy smiles or short teeth, crown lengthening surgery, involving gingivectomy and alveolotomy, can be necessary to improve the aesthetic outcome (7). The precision of these procedures significantly impacts the final result. To achieve high surgical accuracy, the use of surgical guides has become increasingly important (8). These guides help ensure correct tissue removal and proper positioning of the gingival margin, leading to more predictable and aesthetically pleasing results (9).

Root canal treatment can be particularly challenging in cases where tooth structure has been compromised by factors such as decay, trauma, or previous dental procedures. These teeth often exhibit calcification and canal obstructions, making access and canal negotiation difficult. Endodontic guides can be invaluable tools in overcoming these challenges. By providing a visual reference and aiding in instrument navigation, these guides can significantly improve the accuracy and efficiency of root canal treatment. This, in turn, can lead to better clinical outcomes and increased patient satisfaction (10, 11).

Beyond endodontics, dental guides have diverse applications across various dental procedures. They are used in implant surgery to ensure precise implant placement, in periodontics for guided tissue regeneration, and in prosthodontics for accurate crown and bridge fabrication. By providing a standardized approach to guide utilization, clinicians can enhance the predictability and success of these treatments.

The increasing precision demanded in contemporary dental procedures has necessitated the development of various types of surgical guides. These tools enhance accuracy and predictability, ultimately improving patient outcome (12,13). However, a standardized classification system for these guides has been lacking. This article proposes a classification system that categorizes dental guides based on their primary clinical application (12, 14-18). Figure 1 provides a summary of the topics reviewed in this study.

2. Materials and Methods

comprehensive literature search was conducted in the following databases: PubMed Central, Web of Science and Google Scholar. The search timeframe was limited to articles published between 2010 and 2024. The following keywords was employed: "Crown Lengthening", "Computer-Aided Design", "Periodontal Surgery", "Computer-Aided Manufacturing", "Dental Implantation, Surgical", "Surgical Guides", "Tooth Preparation", "Surgical guide".

A total of 1,303 articles were initially identified. Subsequently, a rigorous screening process was applied, involving title and abstract review, as well as the application of the following inclusion and exclusion criteria: Articles published from 2010 onwards were included. Studies not written in English and Studies without accessible full-text versions were excluded. After applying these criteria, a final selection of 62 articles was made for detailed review.

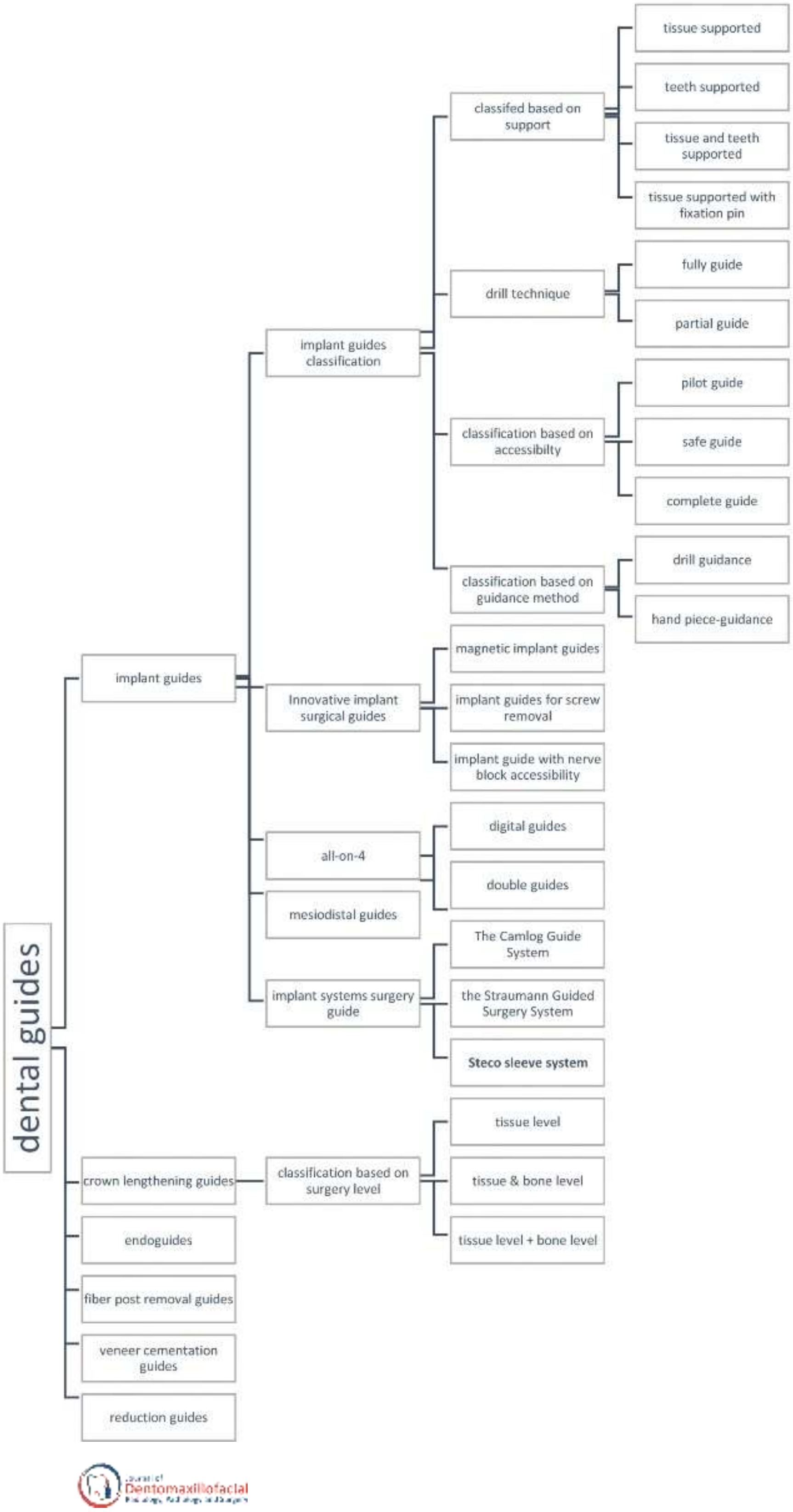

Figure 1. Types of dental guides

3. Results

The literature search yielded 94 articles from Scopus (n=48), PubMed (n=39), and Web of Science (n=7). After removing duplicates, 75 articles were independently assessed by two reviewers based on predefined inclusion and exclusion criteria. Initial screening of titles and abstracts resulted in the inclusion of 64 relevant studies. We have thoroughly examined all 62 articles and developed a new categorization for dental guides.

4. Discussion

Implant surgical guides are essential tools in modern dentistry, enhancing precision and predictability during implant placement. These guides come in various types, each designed to address specific clinical needs (19, 20). Different classification systems have been proposed to categorize implant surgical guides (21).

One common approach considers factors such as access, support, and angle determination. Access can be free, pilot-guided, or fully guided, while support can be mucosal, bone, tissue, or a combination of that. Angle-determining guides provide precise control over implant angulation, while non-angle-determining guides rely on other factors for accurate placement (22).

Early classifications of surgical guides often focused on the degree of edentulism. For instance, guides were categorized based on whether they were used for completely edentulous, partially edentulous with removable prostheses, or partially edentulous with tooth-supported restorations. While these classifications have historical significance, modern approaches consider a broader range of factors to optimize guide design and clinical application (23).

In recent years, a new classification system has emerged for surgical guides, categorizing them based on the level of access they provide. Free guides offer limited guidance, allowing the surgeon to determine implant position and angulation manually. Pilot guides provide more control, guiding the initial drill placement. Complete drill guides offer the highest level of precision, guiding the entire drilling process and ensuring accurate implant placement. By understanding these distinctions, clinicians can select the most appropriate guide for individual patient needs and achieve optimal outcomes (21, 24).

The type of support for a surgical guide is crucial for its accuracy and stability. It can rely on tissue, teeth, a combination of both, or tissue with additional fixation pins (25). The number and placement of fixation pins significantly impact the guide's precision, especially in terms of implant angulation and depth (26). Pessoah et al. (25) emphasized the importance of fixation pins in increasing the accuracy of horizontal placement of the apical part of implants and placement depth. A minimum of three fixation pins, strategically positioned in the midline and lateral areas, is generally recommended for optimal accuracy. In full-jaw guides, the number of pins can range from three to five, depending on the complexity of the case (26).

Implant surgical guides can be categorized based on their guidance method: drill-guidance and handpiece-guidance (27). In handpiece-guidance types, the guide is designed to position the handpiece in the correct position (27). Drill-guidance, a more common approach, utilizes sleeves made of materials like PEEK, titanium, zirconia, or chrome-cobalt (28,29). These sleeves, slightly larger than the drill diameter, guide the drilling process to ensure accurate implant placement. However, drill wear against the sleeve can generate particles that may hinder osseointegration (29) . Studies have shown that zirconia sleeves, while less preferred by dentists, produce fewer particles compared to chrome-cobalt sleeves, particularly in posterior regions (29). Proper seating of the sleeve is crucial for accurate guide function. Thorough removal of any residual adhesive or acrylic on the sleeve's surface is essential to prevent misalignment and ensure optimal performance (30)

The field of implant dentistry continues to evolve, with innovative designs emerging for surgical guides. Magnetic guides offer enhanced visibility and accessibility during surgery, while double-stage guides streamline the implant placement process (31). Additionally, some guides incorporate features for removing bone graft screws or administering local anesthesia, improving efficiency and patient comfort (32).

In complex cases, such as those involving sinus lift procedures or the replacement of cemented prostheses, surgical guides can be customized to address specific challenges. Guides can be designed to accurately determine the sinus floor and facilitate bone grafting (14). Dahiya et al. (33) designed an implant surgical guide that included areas for injecting greater palatine and nasopalatine nerve blocks. Considering that placing an implant in the posterior upper region creates an anatomical limitation due to the pneumatized sinus, sinus lift surgery is inevitable. However, determining the sinus boundary is necessary in the lateral sinus lift method. For prosthesis removal, guides can be used to trim the prosthesis to access the abutment screw, ensuring precise and efficient removal. By adapting to the unique needs of each patient, surgical guides contribute to improved outcomes and patient satisfaction (34-37).

Some implant systems have introduced their own specific surgical guides. These implant systems are the Straumann Guided Surgery, the Camlog Guide System**,** Steco Sleeve System, Noble biocare guided surgery, S.I.N guided surgery, Swiss implant systems(SGS) guided surgery and Ariston Dental fully guided surgical system. In the following part of article, three highly utilized systems will be investigated.

This system utilizes four specialized drill handles that fit snugly into the surgical guide's sleeves. Each handle features a cylindrical extension, either 1 mm or 3 mm in length, which accurately transfers the planned implant length to the surgical site (28).

Surgical guides can be classified into sleeve and non-sleeve types. Color-coded sleeve guides are commonly used, with different colors indicating specific drill diameters. For example, gray sleeves typically correspond to a 3.3 mm drill, yellow to 3.8 mm, and purple to 4.3 mm (28).

Another example of a sleeve-based system is the Steco Sleeve System. This system utilizes color-coded sleeves to guide different implant drill sizes (28).

The All-on-4 technique offers a revolutionary approach to full-arch dental rehabilitation. This method utilizes just four implants, strategically placed with two tilted posteriorly, to restore a complete smile. However, traditional full-arch implant procedures often encounter challenges: extended treatment times, high costs, anatomical limitations, and the need for flap surgery (38). The philosophy behind All-on-4 aims to address these concerns. By using long, tilted posterior implants, treatment times are reduced and the need for flaps is eliminated. Additionally, the technique emphasizes immediate implant loading, single-stage surgery (replacing hopeless teeth with implants in one procedure), and precise implant placement and angulation.To achieve these goals, surgical guides become essential tools for All-on-4 implant placement (39).

All-on-4 Implant Surgical Guides can be categorized based on their manufacturing method – digital or custom-made. A 2024 study by Martin exemplifies the digital approach. In this case, following the design of the patient's temporary prosthesis, the surgical guide was designed using BlueSky Plan (V4.9.4 64 bit, BlueSkyBio, Libertyville, IL, USA) and then 3D printed (40).

One complication encountered during All-on-4 surgery is uneven bone, particularly in the upper jaw after long-term tooth loss. To address this challenge, leveling the bone before implant placement is often necessary. The amount of bone reduction depends on creating a suitable smile line and ensuring adequate space for implant placement. (41, 42) To overcome this situation, Tonellini et al. in 2018 proposed the use of "double guides" for All-on-4 surgery. This approach involves designing and fabricating two separate guides – a special guide for ostectomy (bone leveling) and a specific guide for implant placement – using a digital method. Their study demonstrated a high success rate with this double-guide technique (43).

Mesio-distal guides are specifically designed to ensure proper spacing between dental implants and adjacent teeth. These guides are crucial for accurate implant placement, as precise positioning is essential for long-term implant success and optimal aesthetic outcomes. A 2024 study by Mansouri et al. demonstrated the efficacy of mesio-distal surgical guides in improving surgical precision and overall treatment results (44).

Aesthetic crown lengthening surgical guides can be divided into two categories based on their construction technique: Traditional crown lengthening surgical guides (45), Traditional methods involve taking impressions, creating diagnostic wax-ups, and constructing the guide using acrylic or thermoplastic sheets. In contrast, digital methods utilize CBCT scans and intraoral scans to create a digital design, which is then used to fabricate the guide using 3D printing technology (46-48).

Aesthetic crown lengthening guides can also be categorized based on their level of tissue and bone involvement. Some guides are designed to address only the soft tissue, while others consider both soft tissue and bone levels. Dual crown length guides, which consist of separate guides for soft tissue and bone levels, offer the highest level of accuracy and control (49) . A 2024 study by Li et al. (49) confirmed the superiority of dual guides in achieving precise surgical outcomes. Liu et al. (50) introduced a specific type of dual guide that includes a gingivectomy guide for soft tissue positioning and an ostectomy guide for bone reduction, ensuring accurate biological width**.**

The concept of endodontic guides emerged in 2007 as a tool to aid in complex root canal treatments. To design and fabricate these guides, a 3D CT scan of the patient's teeth is acquired. This image is then used to create a digital design of the guide using software like BlueSky Plan (V4.9.4 64 bit, BlueSkyBio, Libertyville, IL, USA). The endodontic guide is designed to approximate the path of the root canal, which can be refined based on the 3D CT scan. To ensure stability, the guide often incorporates several surrounding teeth in its design (11).

Although the use of endodontic guides can simplify complex treatments, they cannot be used in all teeth. Endodontic guides can only be used in teeth with straight roots. Additionally, guides may not be usable in patients who have difficulty opening their mouths. The high cost and difficulty of using guides in posterior teeth are other problems associated with the use of endodontic guides (51).

One of the challenges dentists face in root canal retreatment is removing the post. Among the types of posts, removing fiber posts is more difficult, due to their bond to the tooth. So removal is only possible through mechanical removal (52). The possibility of tooth perforation, excessive removal of dentin structure, gouging, and ledge formation are the most common problems encountered during fiber post removal (52). To minimize these problems, Mo et al. (53) designed special guides in 2023 and evaluated them in a labratory study. In this study, a sleeveless guide with an adapter for the handpiece tip was designed. The results of this laboratory study showed the high accuracy of these guides and suggested that clinicians use these guides for clinical removal of fiber posts.

In a clinical case, Maia et al. (12) designed and used an endodontic guide for the conservative removal of a fiber post. In this study, an intraoral scan and CBCT of the patient were taken, and the coDiagnostiX software (Dental Wings GmbH) was used to design the guide. The final guide was printed, and with the help of the guide, the fiber post was removed very conservatively.

The longevity of veneers is significantly influenced by the quality of pre-cementation and cementation processes. However, the process of preparing and cementing multiple veneers can be time-consuming and prone to errors, which can impact the final aesthetic and functional outcome (54). In 2020, Chen et al. (18) introduced a novel approach using digital guides for veneer cementation. After preparing the veneers, they were placed on a resin-printed model of the patient's teeth and scanned together. A digital guide was designed to position the veneers 2 mm above the gingival margin, incorporating a perforation for venting excess cement. The guide was then 3D printed. During the cementation process, the veneers were placed on the guide, etched, silanated, and cemented. The guide ensured accurate placement and excess cement was removed from the margins and palatal surfaces before final curing. This method offers a streamlined and precise approach to veneer cementation, potentially improving the overall quality and efficiency of the procedure (18).

Dental guides can be employed to precisely control tooth reduction, particularly for partial denture frameworks. By utilizing a surveyor, a survey cast, and a laboratory scanner, a digital design can be created to specify the exact amount of tooth reduction. This digital design is then used to fabricate a physical guide, ensuring accurate and consistent tooth preparation (55).

In addition to correcting the guiding plane, tooth reduction guides can also be used to reduce the area where the reciprocal arm is placed (56). In a similar study in 2022, a scan was taken of the patient's cast, and a tooth reduction guide was designed and printed for the patient using 3D rendering software (Autodesk Meshmixer; Autodesk Research) before the final RPD impression (57).

While traditional tooth reduction guides are often made from acrylic, advancements in technology have enabled the fabrication of metal guides using SLM printing techniques. These metal guides offer enhanced durability and precision (58).

Tooth reduction guides can play a pivotal role in conservative tooth preparation for full mouth reconstructions. By employing digital design tools and intraoral scanning, clinicians can accurately determine the necessary occlusal adjustments and design guides to achieve the desired tooth reduction (17).

In addition to full mouth reconstructions, tooth reduction guides can be utilized for more conservative procedures, such as minimally invasive reduction of protruding anterior teeth. By creating a digital design and fabricating a physical guide, clinicians can ensure precise and controlled tooth reduction (59).

Tooth reduction guides can also be invaluable in veneer preparation. By incorporating vertical and horizontal cuts into the guide, clinicians can visualize the desired tooth reduction and ensure accurate preparation. This approach can enhance the predictability and aesthetic outcome of veneer treatments (60).

Before the widespread adoption of digital technologies, traditional methods were used to create surgical guides. These methods involved taking a diagnostic cast and wax-up, which served as the basis for fabricating guides using acrylic resins or thermoplastic sheets (45).

The advent of digital technology has revolutionized the design and fabrication of surgical guides, significantly improving their accuracy and efficiency. This digital process typically involves three key steps: 3D image acquisition, software-based design, and manufacturing (61).

Acquiring 3D Images: Generally, for creating digital guides, we need an STL file of 3D images for design. This 3D image is obtained using intraoral scanners when only the dental tissue or soft tissue is being treated. However, for guides where the position of the bone, root canals, and post placement is important, the use of CBCT is necessary. In some cases, extraoral scanners can also be used (61, 62).

Software Design: Once the 3D image is acquired, specialized software is employed to design the surgical guide. Popular software options include Exocad (Exocad 2.4, Exocad GmbH, Darmstadt, Germany) (17, 47, 49, 53, 60), Sirona Densply Systems (13) , 3Shape (3Shape Dental System; 3Shape A/S)(18, 55), Materialise (MimicsResearch 21.0 Beta, Materialise NV, Leuven, Belgium)(56) , BlueSky Plan(V4.9.4 64 bit, BlueSkyBio, Libertyville, IL, USA) (11, 34, 63), and Implant Planning software (Invivo v5; Anatomage) (33) . These software tools allow for precise design and customization of the guide to meet specific clinical needs.

Manufacturing: The final step in the digital process of guides is the manufacturing method. In most cases, printers are used. The introduction of printers into the dental world has simplified and accelerated many processes. The printers that are most commonly used utilize SLA technology (27). Kelliny et al.(11) found the use of printers to be accurate and fast in creating endodontic guides. El Kholy et al. (64) in 2019 showed that the use of 3D printed surgical guides in distal extension edentulous areas was much more accurate than guides made using traditional methods. A study by Resende et al. (65) also showed that printed casts were much more accurate than plaster models (Table 1).

Table 1. Introduction of the software used in the design of surgical guides

Designing software	Applications
Exocad (Exocad 2.4, Exocad GmbH, Darmstadt, Germany)	Crown lengthening guide (47, 49), Fiberpost removal guide(53), Tooth reduction guide (60), Implant surgery guide (17)
Materialise (Mimics Research 21.0 Beta, Materialise NV, Leuven, Belgium)	Tooth reduction Guide(56)
Sirona densply software	Crown Lengthening Guide (63)
3Shape (3Shape Dental System; 3Shape A/S).	Cementation Guide (18), Tooth reduction guide(55)
BlueSky Plan (V4.9.4 64 bit, BlueSkyBio, Libertyville, IL, USA)	Guide for finding the abutment screw(64), Implant surgical guide(34), Endoguide (11)
Implant planning software (Invivo v5; Anatomage)	Precise implant surgical guide (33)

5. Conclusion

This comprehensive review has highlighted the diverse range of surgical guides employed in contemporary dentistry. Our analysis reveals that these guides can be broadly categorized into six primary types: implant surgical guides, surgical guides for aesthetic crown lengthening, fiber post removal guides, endodontic guides, veneer cementation guides, and tooth reduction guides.

Within the realm of implant surgical guides, we have identified distinct classifications based on their support mechanisms and the extent of access they provide. Furthermore, the growing prevalence of digitally fabricated guides underscores their superior accuracy compared to traditional methods.

The findings from this review emphasize the pivotal role of surgical guides in enhancing the precision, efficiency, and predictability of various dental procedures. As technology continues to advance, we anticipate further innovations in guide design and fabrication, leading to even more refined and effective treatment outcomes.

Guided dentistry could be divided to static guides and dynamic guides(navigation). This study investigates the static guides in dentistry. For researchers, we suggest to comprehensive review the dynamic guides in dentistry, their applications and their mechanisms.

Ethical Considerations

Not applicable.

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Authors' Contributions

Maryam Jahangiri: Formal analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing-Original draft, Writing-review & editing **Sayed Shojaodin Shayegh:** Data curation, Project administration, Supervision.

Conflict of Interests

None.

Availability of data and material

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