Accuracy and efficiency of guided veneer preparation: a narrative systematic review

Abstract

Aim
The aim of the present study is to investigate the studies published related to precision and efficiency of digital versus conventional guided veneer preparation for optimal preservation of the enamel.

Materials and Methods
Medline-PubMed, Scopus, and Web of Science were analyzed in order to identify randomized controlled trials. Evaluating the outcomes of guided veneer preparation, manual research was performed as well.

Results
A database search produced 1624 records. After removal of duplicates and meticulous examination of titles and abstracts, three papers were included in this systematic review once the reviewers discovered them.

Conclusions
According to available data regarding the guided veneer preparation, it can be considered a conservative treatment for optimal enamel preservation, which does not need a cautionary selection of cases and a skilled dentist. Guided veneer preparation can be enhanced by using additive manufacturing technology. The study concludes that further randomized control trials are needed to assess the effectiveness of guided veneer preparation. In addition, controlled clinical research is necessary to clearly identify predictable clinical protocols and evaluate the long-term outcomes of such guided preparation.

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Keywords

systematic review; veneer; veneer preparation; guided veneer preparation; digital guide.

INTRODUCTION

Porcelain veneers are a conservative treatment for discolored and malformed anterior teeth, diastema correction and other aesthetic demands (1-3). Ceramic veneers have been a successful treatment modality since the 1980s. Since their introduction, different techniques for preparation have been proposed to create adequate space for the restorative material (4-7). In terms of long-term outcomes, ceramic veneers have been correlated with enamel preservation. The literature shows that the presence or absence of enamel is critical and, as a result, conservative veneer preparation is essential (8-10). The relationship between preparation geometry and service longevity in porcelain veneers (PLVs) is not fully understood, and it remains a controversial topic (11, 12). The literature on dental veneers is extensive, but the impact of tooth preparation, aging, veneer type, and resin cement type on their failure in laboratory tests is unclear (13, 14). Veneer preparation using tooth preparation guides is more accurate than other available preparation methods. Preparation Guides fabricated digitally seems to be more precise in veneer preparation as reported in several studies (15-17).

The first generation of veneer preparation techniques involves preparation of facial and incisal edge using calibrated burs. This method aims to reduce tooth structure uniformly, but can lead to aggressive preparation due to not considering the final restoration's position or enamel wear (15, 18, 19). The second generation uses a diagnostic wax up using silicone indices to guide incisal and facial reduction. The second-generation veneer preparation method involves creating the necessary space by considering the proposed restoration material and future anatomy of the restoration (4, 20). The third-generation technique, Gürel's aesthetic pre-evaluative temporary (APT) technique, involves placing a temporary mock-up fabricated via a diagnostic wax-up over the teeth. This allows for faster and more conservative preparation, but has limitations such as subtractive cases requiring pre-reduction and parts dislodging before final veneer application (8, 21, 22).

Digital technology has changed veneer preparation by incorporating natural shapes, printed mock-ups, milled restorations, and facial integration. CAD-CAM design software allows for facial integration, allowing lab technicians and clinicians to check space needed for future restorations during the digital wax-up design phase. This allows real-time feedback on facial esthetics and changes to the plan, which was not possible in traditional analog formats of stone models. (23-27). The incorporation of 3D-printing technology has allowed the development of rigid preparation guides, overcoming limitations of silicone indices of the second-generation variety and improving visualization of teeth. Despite these advancements, traditional veneer preparation still relies heavily on the skill and clinical experience of technicians (28-31).

To date, although guided veneer preparation is becoming more and more popular in prosthetic dentistry for its precise outcomes. Clinical and research evidences seem to be not enough in scientific literature. The purpose of the present systematic review was to evaluate the level of scientific evidence regarding guided veneer preparation.

SEARCH METHODS

The primary objective of this systematic review was to assess the clinical efficacy of a reduction guide for veneers that were prepared using the guided veneer preparation technique.

The second objective was to compare differences in survival rates between subgroups related to the following variables:

- accuracy and fitness of veneer restoration;
- compare the results of different guided veneer types.

The search strategy relied on publications accessible through internet databases, including Medline-PubMed, Scopus, and Web of Science. A comprehensive search was conducted to locate publications published from 2014 to 2024. Only articles written in the English language were taken into account.

The electronic search was made using the following keywords:

- veneer preparation;
- guided veneer preparation;
- digital guided veneer preparation;
- veneer preparation design;
- 3D printed veneer reduction guide;
- veneer preparation guide;
- digital veneer preparation;
- digital veneer guide;
- enhanced veneer reduction guide;
- veneer reduction guide;
- reduction veneer guide;
- digital guided tooth preparation;
- laminate veneer reduction guide;
- laminate veneer preparation guide;
- guided laminate veneer preparation.

In addition to doing a manual search, we also evaluated grey literature available on the website www.opengrey.eu to identify relevant papers.

Two trained and calibrated reviewers conducted data extraction autonomously and any dispute was settled by deliberation with a third supervisor who possessed extensive expertise and was well versed in the subject matter.

INCLUSION CRITERIA

This systematic review was structured following the PRISMA guidelines. The eligibility of investigations was assessed according to the P.I.C.O. process as follows:

Database	Search strategy	Results
Medline-PubMed	((((((((((((((veneer preparation) OR (guided veneer preparation)) OR (Digital guided veneer preparation)) OR (veneer preparation design)) OR (3D printed veneer reduction guide)) OR (veneer preparation guide)) OR (digital veneer preparation)) OR (digital veneer guide)) OR (enhanced veneer reduction guide)) OR (veneer reduction guide)) OR (reduction veneer guide)) OR (digital guided tooth preparation)) OR (laminate veneer reduction guide)) OR (laminate veneer preparation guide)) OR (guided laminate veneer preparation)	876
Scopus	veneer AND preparation OR guided AND veneer AND preparation OR digital AND guided AND veneer AND preparation OR veneer AND preparation AND design OR 3d AND printed AND veneer AND reduction AND guide OR veneer AND preparation AND guide OR digital AND veneer AND preparation OR digital AND veneer AND guide OR enhanced AND veneer AND reduction AND guide OR veneer AND reduction AND guide OR reduction AND veneer AND guide OR digital AND guided AND tooth AND preparation OR laminate AND veneer AND reduction AND guide OR laminate AND veneer AND preparation AND guide OR guided AND laminate AND veneer AND preparation AND (LIMIT-TO (LANGUAGE , "English"))	30
Web of science	((((((((((((((ALL=(veneer preparation)) OR ALL=(guided veneer preparation)) OR ALL=(digital guided veneer preparation)) OR ALL=(veneer preparation design)) OR ALL=(3D printed veneer reduction guide)) OR ALL=(veneer preparation guide)) OR ALL=(digital veneer preparation)) OR ALL=(digital veneer guide)) OR ALL=(enhanced veneer reduction guide)) OR ALL=(veneer reduction guide)) OR ALL=(reduction veneer guide)) OR ALL=(digital guided tooth preparation)) OR ALL=(laminate veneer reduction guide)) OR ALL=(laminate veneer preparation guide)) OR ALL=(guided laminate veneer preparation)	718

Tab. 1 Search strategy for each database and relative results

Participants

- dental veneer restoration of maxillary or mandibular teeth

Interventions

- Randomized clinical trials (RCTs) evaluating the precision and fitness of guided veneer preparation.

Comparison

- RCTs comparing veneers made by conventional methods
- RCTs comparing guided veneer reduction with digital veneer reduction guide.

Outcomes

- precision and accuracy of veneers made by reduction guide
- comparison between the precision and accuracy between veneers made by different types of reduction guides.

Quality assessment

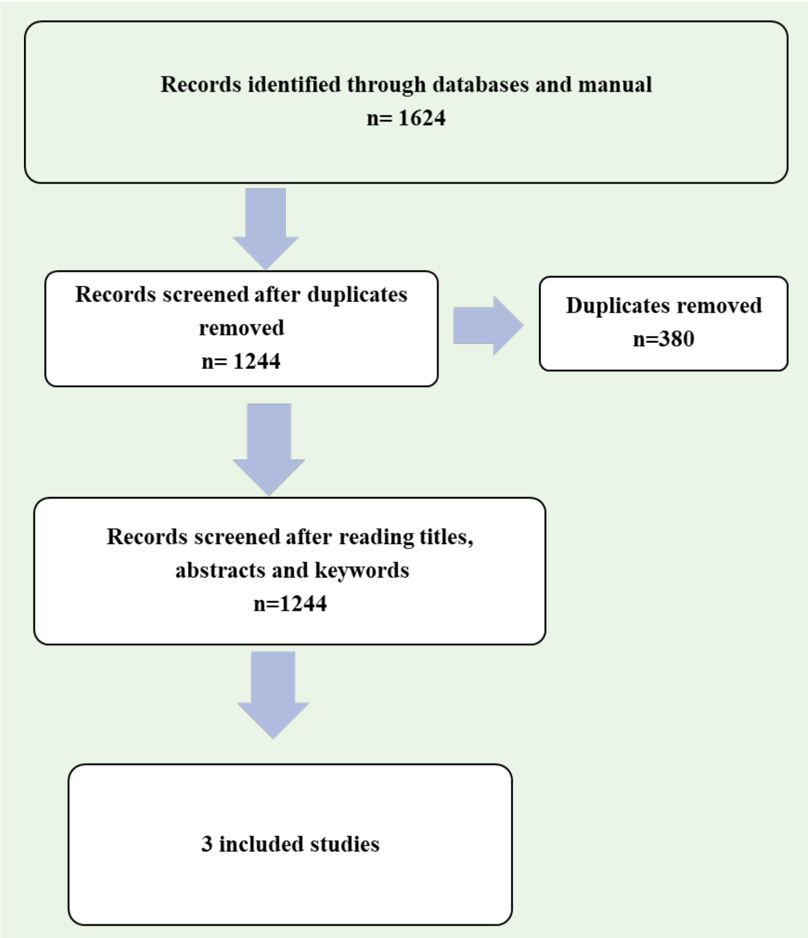
The quality assessment of the included studies was carried out using the criteria reported by the Cochrane Handbook for Systematic Reviews of Interventions (32) as follows:

- Evaluation of random sequence generation (selection bias):
  0: no randomized
  1: unclear risk
  2: random component in the sequence generation process
- Evaluation of allocation concealment (selection bias):
  0: participants could possibly foresee assignments
  1: unclear risk
  2:participants and investigators enrolling participants could not foresee assignment
- Evaluation of blinding of participants and personnel (performance bias):
  0: inadequate
  1: unclear
  2: adequate
- Incomplete outcome data (attrition bias):
  0: missing data
  1: unclear risk
  2: no missing data outcome
- Selective reporting (reporting bias):
  0: yes
  1: unclear
  2: no/not possible
- Evaluation of other bias:
  0: potential source of bias
  1: insufficient information
  2: the study appears to be free of other sources of bias.

The risk of bias was evaluated based on quality criteria, allocation concealment, and blinding of outcome assessor, following the guidelines outlined in the Cochrane Handbook for Systematic Review of Interventions (32).

SEARCH RESULTS

The search methodology and the corresponding outcomes were documented in Table 1. The database investigation yielded 1624 records, included some



Tab. 2
Workflow of the paper screening process

duplicates. However, the grey literature and manual search did not provide any further relevant studies. After eliminating all the duplicates, all of the chosen databases yielded a total of 1244 records. The procedure for the paper screening process was documented in Table 2. After thoroughly examining the titles, abstracts, and keywords, the reviewers have chosen three articles that match the inclusion criteria for the current systematic review. These studies are provided in table 3.

DISCUSSION

The use of guided veneer preparation for laminate veneers is a reliable and conservative procedure that has been shown to have strong long-term durability and a low rate of complications. This has been proven by several research studies and clinical studies, which have consistently demonstrated predictable outcomes. Fractures, micro leakage, and debonding were the most frequently reported failures associated with conventional guided veneers (5, 28, 33, 34). Different factors affect the survival of ceramic veneers such as mechanical properties of the restoration, cementation material occlusal forces, cavities and preparation design (35-37). There have been a variety of tooth preparation geometries documented in the scientific literature and the relationship between the design of the preparation and the sort of failure is still a subject of debate (19, 38). The biomechanical and esthetic properties of ceramic veneers are both influenced by guided tooth preparations, as has been extensively noted (39). The loss of uncontrolled tooth structure compromises the flexibility of restoration, leading to higher levels of stress and strain (40-42). Additionally, achieving a seamless optical transition between the tooth and the replacement becomes more challenging when there is an uneven thickness in the restoration (43, 44).
Zhong et al. (2020) conducted a study using 20 resin artificial teeth of the maxillary central incisor. These teeth were randomly divided into two groups of identical size and prepared for laminate veneers. In the test group, tooth preparation was performed using a 3D printed guide, as shown in figure 1, whereas in the control group, depth gauge burs were used. Both groups finished the preparation using freehand operation. The teeth were 3D scanned before preparation, after the initial preparation, and after the final preparation. 3D deviation analysis was used to measure the tooth preparation depth at each phase, which includes the initial preparation depth, final preparation depth, and loss of tooth tissue after polishing. The study's findings revealed a significant statistical difference between both

Author	year	Journal	Results
Zhong et al.	2020	Chinese journal of dental research.	3D-printed rigid constraint guides provide better accuracy in tooth preparation for laminate veneers than depth gauge burs in maxillary central incisor teeth.
Luo et al.	2022	Journal of prosthetic dentistry	The depth cutter bur (0.5 mm) technique presented the most accurate reduction result among other protocols examined in the study.
Gao et al.	2023	Journal of Prosthodontic Research.	Using tooth preparation guides improved veneer preparation accuracy compared to freehand methods. The 3D printed auto-stop guide had the lowest absolute difference (0.05 mm), whereas the silicone guide had the biggest absolute difference in preparation (0.12-0.16 mm).

Tab. 3 The studies included in this systematic review

groups (P<0.05). The test group had a final preparation depth of 0.547±0.029mm, which was significantly less than the control group's depth of 0.599±0.051mm (P<0.05). The test group's depth was also closer to the predesigned value of 0.5 mm. There was no statistically significant difference in the amount of tooth tissue lost throughout the polishing procedure between the test group (0.072±0.023mm) and the control group (0.089±0.038mm). Concluding that using 3D-printed rigid constraint guides is more accurate than using depth gauge burs to prepare teeth for laminate veneers in the maxillary central incisor teeth (45).

A study done by Tian Luo et al. (2022) using A consistent 0.3-mm layer of digital wax was applied to the front surface of 30 typodont incisors in the maxillary central region using a software tool. The trial restorations were created on typodont teeth using auto-polymerizing acrylic resin. This was done by utilizing a silicone index that was based on 3-dimensionally printed casts, which were produced from the digital waxing process, as shown in figure 2. The 30 maxillary central incisors have been divided into 3 groups: the depth cutter (0.5 mm) (DC) group, the round bur (1.5 mm) (RB) group, and the specially designed calibrated depth bur (0.5 mm, G) (CD) group. The three groups were randomly assigned using a random number table by two skilled prosthodontists in order to achieve a uniform facial clearance of 0.5 mm. The software program measured and evaluated the dimensional changes in the standard tessellation language (STL) files between the surfaces of the original teeth, digital waxing, trial restorations, and prepared teeth. The measurements were taken at the same nine spots on the labial surface. A one-way analysis of variance (ANOVA) with a post hoc test was used to find important differences between trial restorations and waxing. Evaluation for differences in the reduction depth of typodont teeth (RDT) and the reduction depth (RD) between the three methods was done. The significance level (alpha) was set at 0.05. The accuracy (percentage) was determined by calculating the mean relative differences (MRDs). The results showed statistically significant differences in reduction depth (RD) that have been noted across the three guided techniques (P<.05). The depth cutter bur group (DC) achieved the most accurate result of 0.51 ±0.08 mm, with a mean relative differences (MRD) measurement of 2%. In contrast, the round bur group (RB) was given results of 0.57 ±0.10 mm with an MRD of 14%, and group DC obtained data of 0.60 ±0.11 mm with an MRD of 20%. Concluding that the depth cutter bur technique with the silicone index provided the most accurate tooth preparation than the round bur and specially designed calibrated depth bur techniques used in this study (46).

Gao et al. (2023) did a research using fifty artificial teeth made of resin were divided into five groups (n = 10) in a random manner. The groups included a freehand group (F), a silicone guide group (S), a thermoplastic guide group (T), a 3D printed uniform guide group (D), and a 3D printed auto-stop guide group (A) as shown in figure 3. Two operators utilized tooth preparation guides to do a window veneer preparation on the maxillary right central incisor. The maxillary right central incisors were scanned both before and after the preparation. The depths of reduction were measured in three specific areas of the prepared surface: the cervical, middle, and incisal thirds. Depth maps were then generated using

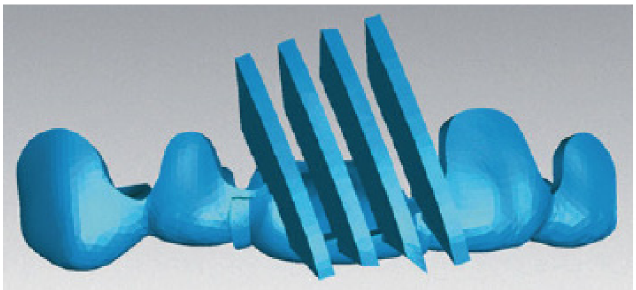


Fig. 1 3D image of tooth preparation guide with complementary guiding structure (45).

Geomagic Control X software. The accuracy of the reduction depths at each third was assessed by using both trueness and precision values. The trueness of the reduction depths was determined by calculating the mean absolute differences (MADs) in comparison to the planned depth, while the precision was measured by the standard deviation (SD). The data acquired underwent statistical analysis using one-way ANOVA and the least significant difference test ($\alpha = 0.05$). They found that using tooth preparation guides offer more precision and improved veneer preparation compared to freehand preparation method. Out of the four guides, the 3D printed auto-stop guide had the least absolute difference of 0.05 mm, while the silicone guide had the highest absolute difference in preparation (47).

Laminate veneers show superior results regarding fitness and accuracy when the preparation was done using 3D printed rigid constraint reduction guide providing conservative and predictable treatment option that preserves enamel tissues (18). While tooth preparation may vary based on the need for masking and the required thickness of the material, it is advisable to minimize dentin exposure to minimize the possibility of failures (48).

Within the field of digital dentistry, there is a growing trend towards using digital guided veneer preparation. This approach has several beneficial effects, including the preservation of enamel and the ability to create restorations with optimal mechanical properties. Additionally, it provides improved precision and accuracy (45, 47, 49).

Although ,reducing working time and number of visits can be considered a beneficial advantage of such treatment option The cementation process for laminate veneers can be improved by utilizing a digital guide (15, 28)

The use of digitally generated guides for reduction in anterior teeth offers a significant benefit when combined with digital smile design software, resulting in flawless esthetic outcomes (50-52). It is likely that this technique will be helpful in repositioning the teeth in order to lessen the inclination of the teeth and to make the preparation of the veneer as little than feasible(53). Although, guided veneer preparation has been reported to yield superior results, this procedure necessitates the use of extra equipment and the expertise of a dental technician lab, for these reasons, conventional veneer preparation is sometimes regarded as a simpler approach that really represents processes that are sensitive to the operator. This is mostly owing to the fact that it is frequently difficult to create a form that is relatively natural and harmonious (5, 54).

However, the thin restoration margins, which are approximately 0.3 millimeters in thickness, are at a high risk of chipping during handling, both in the dental laboratory and in the dental office. Furthermore, the bonding procedure may result in the veneers

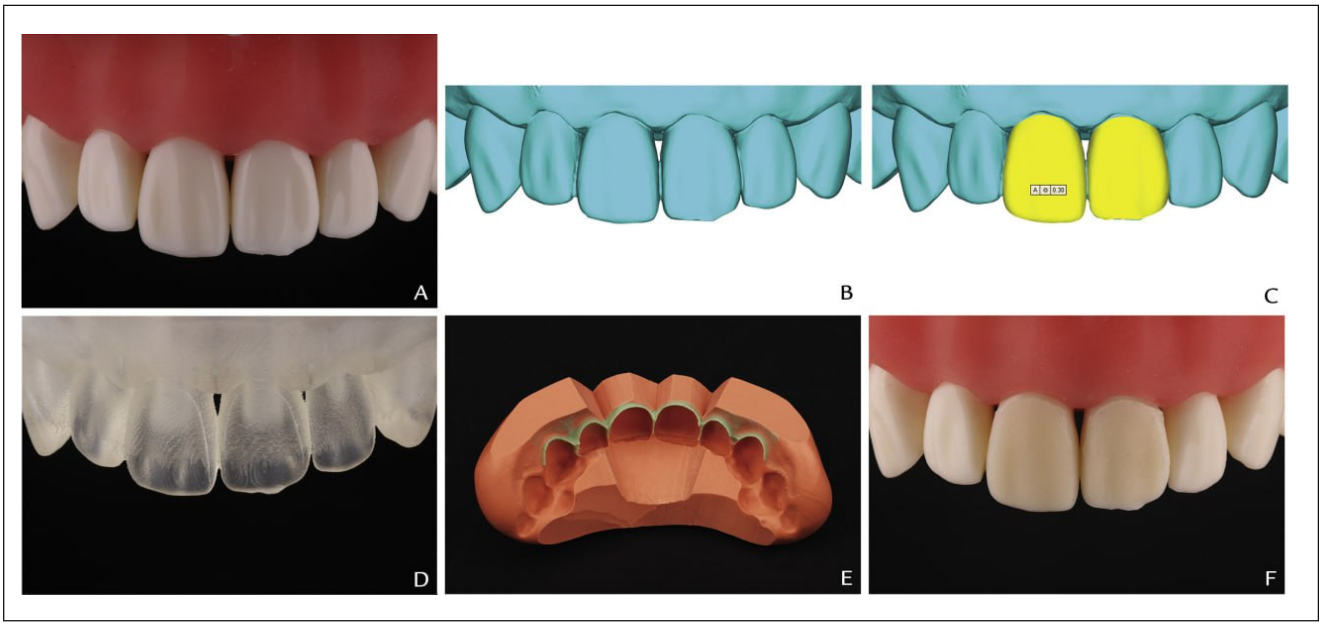


Fig. 2 Fabrication procedure of trial restorations. **(A),** Original typodont teeth. **(B),** Digital cast of original typodont teeth. **(C),** Digital waxing. **(D),** 3D-printed cast of waxing. **(E),** Silicone index. **(F),** Teeth with trial restorations (46).

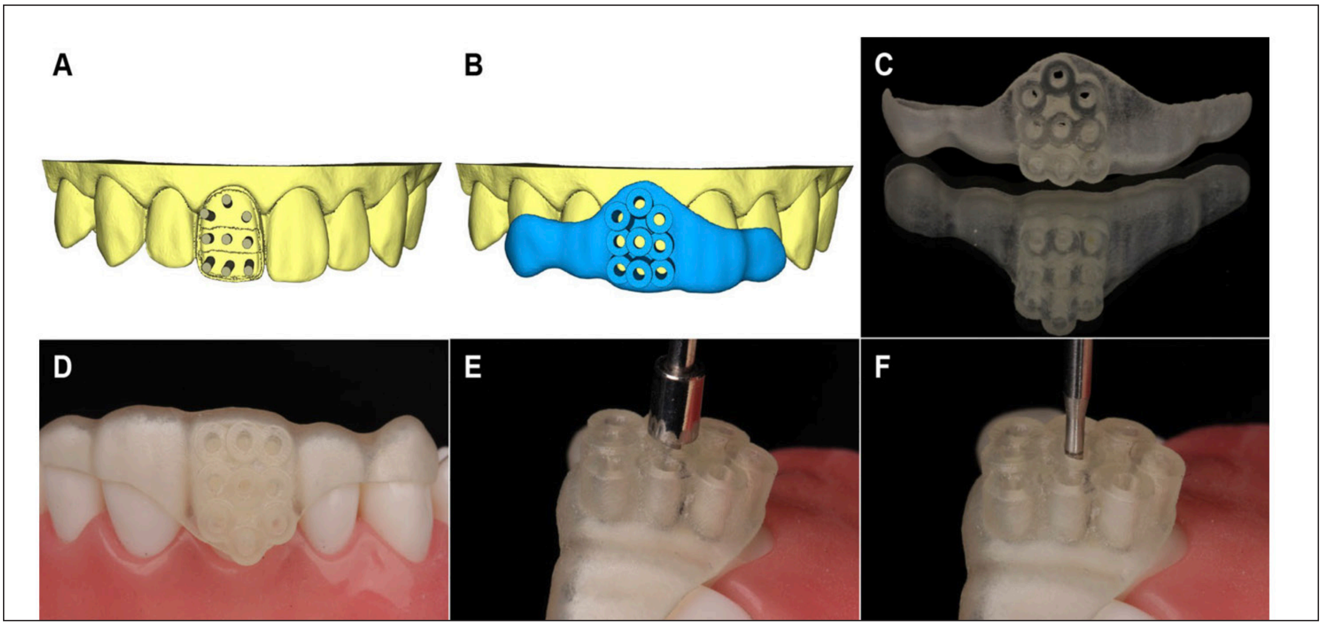


Fig. 3 Tooth preparation assisted by the 3D-printed auto-stop guide. **(A-C)** Manufacture process of 3D-printed auto-stop guide. **(D-F)** Depths controlling process assisted by the 3D-printed auto-stop guide (47).

breaking due to the shrinkage that occurs during the polymerization of resin cements (55-57).

Through the use of guided veneer preparation, the thickness of the restoration margins may be carefully controlled. This allows for the relatively high danger of chipping to be reduced by managing the thickness of the restoration in any part of the veneer restoration (5, 7, 58).

The primary problems that have been described in veneer restoration include secondary caries, bleeding on probing, discoloration of margins, fractures or cracks, loss of retention, and hypersensitivity (55, 59, 60).

Using guided veneer reduction technique can enhance accuracy and fitness of restoration so, such problems can be apparently minimized for better survival rate of veneer restoration (61). While there were no specifically listed contraindications to guided veneer preparation in the papers that were retrieved, further research on the technique's long-term effects is necessary because the majority of the studies were case reports (62).

Guided veneer preparation was the focus of this systematic review, which aimed to examine its clinical validity by reviewing relevant scientific literature. There were three randomized controlled trials (RCTs) available on this topic.

Moreover, practitioners must employ this technique frequently. The use of this approach may yield greater clinical outcomes, which are in contrast to the esthetic demand of the patients Furthermore; there is little support for its predictability from either clinical or scientific research.

Authors propose the following recommendations for further investigations and clinical research:

- Determine the efficacy of veneer restoration survival rates using guided veneer preparation and conventional veneer preparation procedures.
- Studies on the effects of use various types of reduction guides.
- Conducting investigations to examine the impact of guided veneer preparation on various dental veneer materials.

CONCLUSION

Based on the findings of this investigation, three papers fulfilled the inclusion criteria of this systematic review. Currently, there is a lack of a definitive and obvious clinical statement on this topic. Due to the lack of available scientific and clinical data. Within the boundaries of this systematic review, guided veneer preparation need to be taken into consideration as a treatment option that is both conservative and accurate. Additional randomized controlled trials are required to definitively establish standardized clinical protocols and assess the clinical efficacy and long-term results of guided veneer preparation.

Conflict of interest

The authors declare no conflict of interest.

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