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REVIEW ARTICLE

Digital dentistry and guided treatments: a concise systematic review

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Abstract

Introduction: In the landscape of new digital technologies, many dental treatments have benefited from this digital advance. The development of computed tomography (CT) dental scanners has enabled powerful imaging capabilities and software applications. The prosthetic plane and implanted drill guides with the placement of trajectories based on a drill according to the position of the CT 3-D Space markers. **Objective:** To present, through a systematic review, the main considerations of guided surgery in implant dentistry and its respective advantages, disadvantages, and limitations. **Methods:** Clinical studies with qualitative and/or quantitative analysis were included, following the rules of the systematic review-PRISMA. **Results:** Out of a total of 102 articles found, 82 articles were evaluated and 57 were rejected for not meeting the GRADE classification, and only 25 articles were used in this study to compose the textual part. Advances in technology have contributed to the improvement of implant models. 3D reconstructions make it possible to determine the quantity and quality of available bone and also enable the simulation of implant installation in a virtual environment, reducing time and the possibility of errors, allowing for an overall reduction in the costs of oral rehabilitation. **Conclusion:** Guided preoperative planning or project-guided dental surgery provides high implant and dental rehabilitation success rates, also benefiting prosthetic restorations supported by fixed implants. Furthermore, the concept of using personalized implants with the help of 3D virtual treatment planning improves mandibular restoration with a good facial profile, esthetics, and dental rehabilitation.

Keywords: Digital technologies. Computed tomography. Dental scanners. Guided surgery. Project-guided dental surgery.

Introduction

In the scenario of new digital technologies, several dental treatments have benefited from this digital advance. The development of computed tomography (CT) dental scanners has enabled powerful imaging features and software applications, implementing guided dentistry [1]. In this regard, authors and other investigators developed computer planning methods to relate CT data to the prosthetic plane and implanted drill guides with the placement of trajectories based on a drill according to the position of the markers in the 3-D space of the CT [2,3].

In this context, the Software developed by Columbia Scientific known as SimPlant made the planning of these cases possible. After the acquisition of Columbia Scientific by Materialize (Leuven, Belgium), they had a process to use rapid-output manufacturing of the software-planned dental implant trajectories in bone and later surgical drill guide teeth [4]. In this context, the optimization of faster and more accurate techniques by dental and postoperative surgeons with better results and quality of life stimulated the development of numerous software and hardware for the performance of computer-guided (CG) surgeries [4,5].

In this aspect, the software allows the placement of implants, as well as the creation of a high-precision surgical guide for the placement of implants and prostheses in immediate load on patients [5]. However, the accuracy of guided surgery systems for the placement of dental implants depends on a number of cumulative and interactive factors, which can lead to errors [5-11]. Despite this, CG allows the protection of critical anatomical structures, as well as aesthetic and functional advantages that come from placing the implant in the location determined by the prosthesis [12].

Furthermore, GC is indicated in cases where CT is recommended as a diagnostic tool, when precise implant placement is imperative, and when implants with longer lengths are desired for the optimal use of available bone [13]. Thus, reconstruction technologies have expanded to include the use of guided surgical planning and computer-assisted design and manufacturing (CAD-CAM), and three-dimensional printing [14-17].

This study aimed to present, through a systematic review, the main considerations of guided surgery in implant dentistry and its respective advantages, disadvantages, and limitations.

Methods

Study Design

The present study was followed by a systematic literature review model, according to the PRISMA rules [18].

Data sources and research strategy

The search strategies for this review were based on the descriptors: "Digital technologies. Computed tomography. Dental scanners. Guided surgery. Project-guided dental surgery". The research was carried out from July 2021 to September 2021 and developed based on Google Scholar, Scopus, PubMed, Scielo, and Cochrane Library.

Study quality and risk of bias

The quality of the studies was based on the GRADE instrument [19], with randomized controlled clinical studies, prospective controlled clinical studies, and studies of systematic review and meta-analysis listed as the studies with the greatest scientific evidence. The risk of bias was analyzed according to the Cochrane instrument [20].

Results and Discussion

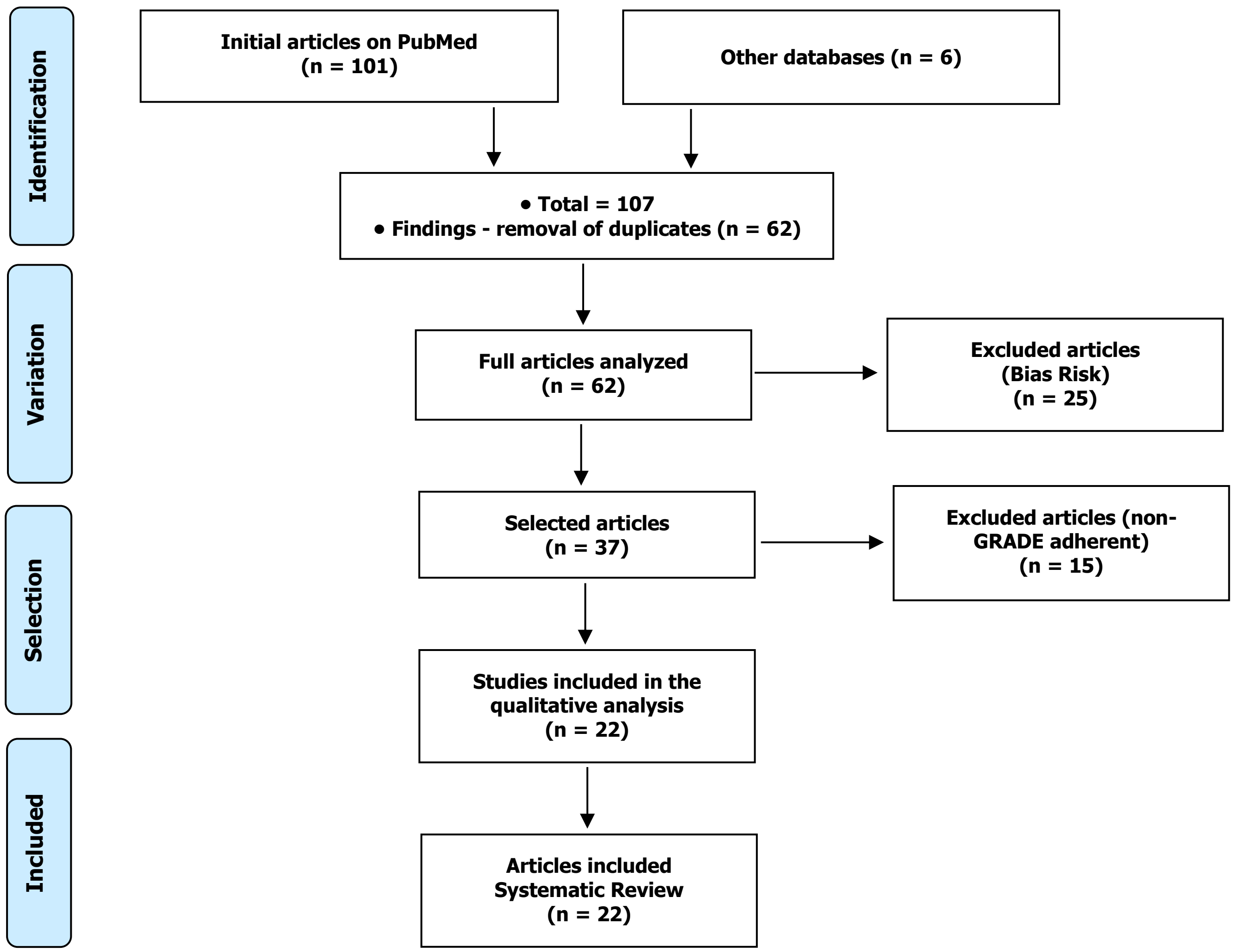
Figure 1 shows that out of a total of 107 articles found, 62 articles were evaluated and 37 were rejected for not meeting the GRADE classification, and only 22 articles were used in this study to compose the textual part. Based on the main literary findings, advances in technology have contributed to the improvement of implant models [1]. 3D reconstructions allow to determine the quantity and quality of available bone and also allow the simulation of implant installation in a virtual environment, reducing the time and the possibility of errors, allowing the overall reduction of the costs of oral rehabilitation [2]. In this sense, the most used imaging exam in dentistry capable of providing bio models is CT, which allows for a three-dimensional assessment of the individual anatomy of patients [10].

In this sense, a study with 25 patients compared fully guided implant surgery with the conventionally guided one in terms of the deviation of the actual implant position from the ideal implant position. There were statistically significant differences between the ideal and real position of the implant in the apical facial-lingual deviation and for the facial-lingual angular deviation, where the conventional guided group deviated more from the ideal position than the full guided group [21].

Also, a study evaluated the accuracy of the implant position using surgical guides made by additive and subtractive techniques. There were no significant differences in the accuracy of implant placement using guides fabricated with additive versus subtractive techniques. The mean angular deviations between the reference and the actual position of the implant in the mesiodistal section were 0.780 ± 0.80 ° for the printed group and 0.77 ± 0.72 ° for the milled group. The differences in the buccolingual cross-section were 1.60 ± 1.22 ° in the printed group and 1.77 ± 0.76 ° in the reamed group. Depth differences (mm) were measured in the upper part of the scan body at four locations: mesial, distal, buccal, and lingual. The mean differences in-depth for the group that used printed surgical guides were (mesial) 0.37 ± 0.29 mm, (distal) 0.32 ± 0.23 mm, (buccal) 0.24 ± 0.23 mm and (lingual) 0.25 ± 0.17 mm. The mean differences in-depth for the group that used reamed surgical guides were (mesial) 0.51 ± 0.33 mm, (distal) 0.40 ± 0.32 mm, (buccal) 0.22 ± 0.23 mm and (lingual) 0.23 ± 0.12 mm in these four aspects, respectively. The mean coronal deviation showed 0.32 mm in the printed group and 0.27 mm in the reamed group. For the apical deviation, the results of this study showed a mean apical deviation of 0.84 mm in the printed group and 0.80 mm in the reamed group [22].

Besides, a systematic review study analyzed the accuracy of implant placement using computer-guided surgery and compared the design and outcome of virtual treatment versus in vitro, clinical, or cadaver studies. Also, it compared the accuracy of half-guided implant surgery with that of fully guided implant surgery. A total of 186 articles were reviewed, and 34 met the inclusion criteria. Information on 3,033 implants was analyzed in 8 in vitro studies (543 implants), 4 cadaver studies (246

Figure 1. The selection process of scientific articles.



implants), and 22 clinical studies (2,244 implants). Significantly fewer horizontal apical deviations and angular deviations were observed in in vitro studies compared to clinical and cadaver studies, but there were no statistically significant differences in apical coronal deviation or vertical deviation between groups. Compared with semi-guided surgery, fully guided implant surgery showed significantly less horizontal coronal deviation for cadaver studies, significantly less horizontal apical deviation for clinical studies, and significantly less angular deviation for clinical and cadaver studies [23].

Also, a meta-analysis study analyzed the accuracy of dynamic computer-aided implant surgery (dCAIS) systems when used to place dental implants and compared their accuracy with static computer-aided implant surgery (sCAIS) and placement systems. freehand implants. Of 904 potential articles, the 24 selected evaluated 9 different dynamic navigation systems. The global mean and 3D angular deviations from entry for clinical studies were 3.68° and 1.03 mm, respectively. No significant differences were found between the different dCAIS systems. These systems were significantly more accurate than the sCAIS and freehand implant placement systems. As such, dCAIS systems allow the placement of high-precision implants with an average angle of less than 4° [24].

Added to this, the literature shows that there is a program for the reconstruction of the 3D bio model (MIMICS®) and another for the production of surgical guides (3-Matic®). MIMICS® is a biomodeling program and is very fast and intuitive, showing the ability to separate parts in which there are no interconnections and subtractions, without resorting to model generation. 3-Matic®, on the other hand, has specific design tools, which make it relatively simple to model a prosthesis, as it uses triangular mesh and not curved surfaces, which are quite difficult and time-consuming to model [15].

In this context, the concept of using personalized implants with the help of 3D virtual treatment planning, stereolithographic models, and computer-assisted design greatly improves mandibular restoration and helps to achieve a good facial profile, esthetics, and dental rehabilitation preventing serious complications related to autologous grafts [17].

Also, a randomized study compared the precision of guided planning of new computer-assisted implant placement techniques, based on models that use CAD/CAM stereolithographic surgical models with or without metallic sleeves. No implants failed and there were no complications. Forty-one implants were placed using surgical templates with metal sleeves, while 49 implants were placed using a surgical mold without metal sleeves. There was a statistically significant difference in the angle and the vertical plane, with lower values for implants placed with a surgical mold without metallic sleeves. In the test group, closed sleeves were more accurate compared to sleeves open in the angle and the horizontal plane [20].

Also, some programs can fix these errors like MeshFix, MeshWorks, and Autodesk Netfabb. Featured for Autodesk Netfabb which was able to fix the open contours and other problems that the model. However, when these defects were corrected, this program assumed that the holes made in the model, for subsequent surgical guidance, were open contours, which were automatically closed. Another problem that arose when using this program was that the model failed to fit the patient's mouth [25].

Conclusion

Guided preoperative planning or project-guided dental surgery provides high implant and dental rehabilitation success rates, also benefiting prosthetic restorations supported by fixed implants. Furthermore, the concept of using personalized implants with the help of 3D virtual treatment planning improves mandibular restoration with a good facial profile, esthetics, and dental rehabilitation.

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Data sharing statement

No additional data are available.

Conflict of interest

The authors declare no conflict of interest.

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