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Original Research Article

In Vitro Comparison of Guided Versus Freehand Implant Placement: use of A CBCT

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Abstract:

Background: Implant dentistry has evolved significantly, with guided implant placement emerging as a promising technique. This study aims to compare the accuracy and efficacy of guided implant placement against freehand techniques using Cone Beam Computed Tomography (CBCT) imaging.

Materials and Methods: Twenty patients from SIMS Department of Dentistry, requiring single-tooth implants were randomly assigned to either the guided implant placement group or the freehand placement group. CBCT scans were utilized for treatment planning and assessment of implant placement accuracy. Surgical guides were fabricated for the guided group based on preoperative CBCT data. Implant placement deviations were measured in three dimensions: mesiodistal, buccolingual, and apicocoronal.

Results: In the guided group, the mean deviation in implant placement was 0.75 mm mesiodistally, 0.5 mm buccolingually, and 0.3 mm apicocoronally. In contrast, the freehand group exhibited a mean deviation of 1.5 mm mesiodistally, 1.2 mm buccolingually, and 0.8 mm apicocoronally. Statistical analysis revealed significantly lower deviation values in the guided group across all dimensions ($p < 0.05$).

Conclusion: Guided implant placement utilizing CBCT technology offers superior accuracy compared to freehand techniques. The use of surgical guides allows for precise implant positioning, minimizing deviations and enhancing clinical outcomes. Incorporating CBCT into treatment planning enhances predictability and facilitates optimal implant placement.

Keywords: Guided Implant Placement, Freehand Implant Placement, Cone Beam Computed Tomography (CBCT), Accuracy, Surgical Guides.

Introduction

Implant dentistry has witnessed significant advancements in recent years, with guided implant placement emerging as a promising technique for enhancing accuracy and predictability [1]. Traditional freehand implant placement relies heavily on the clinician's skill and experience, which may lead to variable outcomes and potential deviations from the planned implant position [2].

In contrast, guided implant placement utilizes advanced imaging modalities such as Cone Beam Computed Tomography (CBCT) to precisely plan implant placement and fabricate surgical guides that dictate the exact positioning of implants during surgery [3].The use of CBCT imaging allows for comprehensive three-dimensional evaluation of the implant site, including bone density, morphology, and adjacent anatomical structures [4]. This detailed preoperative assessment enables clinicians to identify potential challenges and plan optimal implant placement trajectories to achieve favorable clinical outcomes [5].

While several studies have demonstrated the efficacy and accuracy of guided implant placement compared to traditional freehand techniques, further

investigation is warranted to provide additional evidence and insights into the clinical benefits of guided implant surgery [6, 7]. This study aims to contribute to the existing body of literature by conducting an in vitro comparison of guided versus freehand implant placement using CBCT imaging, with a focus on evaluating accuracy and precision.Through a comprehensive analysis of implant placement deviations and clinical outcomes, this study seeks to elucidate the potential advantages of guided implant placement and its implications for enhancing treatment predictability and patient satisfaction in implant dentistry.

Materials and Methods

Study Design: This study utilized an in vitro experimental design to compare guided implant placement against freehand techniques using Cone Beam Computed Tomography (CBCT) imaging.

Participant Selection: Twenty patients SIMS Department of Dentistry, requiring single-tooth implants were recruited for this study. Inclusion criteria included good oral health, adequate bone volume for implant placement, and absence of systemic diseases affecting bone metabolism. Patients with a history of craniofacial trauma or surgery were excluded from the study.

Group Allocation: Participants were randomly assigned to either the guided implant placement group or the freehand placement group using a computer-generated randomization scheme.

CBCT Imaging:

All participants underwent CBCT scanning using a standardized protocol. The CBCT images were acquired with a voxel size of 0.25 mm^3 to ensure high-resolution three-dimensional visualization of the implant site.

Treatment Planning: For the guided implant placement group, CBCT data were imported into computer-aided design (CAD) software for virtual treatment planning. Implant positions and trajectories were planned to optimize bone-to-implant contact and esthetic outcomes. Surgical guides were fabricated based on the virtual treatment plan using computer-aided manufacturing (CAM) techniques.

Surgical Procedure: Implant surgery was performed under local anesthesia by experienced oral surgeons. In the guided group, surgical guides were used to dictate the precise positioning and angulation of implants according to the virtual treatment plan. In the freehand group, implants were placed using traditional freehand techniques based on clinical judgment and experience.

Assessment of Implant Placement: Following implant placement, CBCT scans were obtained to assess the accuracy of implant placement. Deviations from the planned implant positions were measured in three dimensions: mesiodistal, buccolingual, and apicocoronal.

Statistical Analysis: Descriptive statistics were calculated for implant placement deviations in both groups. Mean deviations and standard deviations were compared between the guided and freehand groups using independent t-tests. Statistical significance was set at $p < 0.05$.

Results

The results of implant placement deviations in the guided and freehand groups are summarized in Table 1.

Table 1: Implant Placement Deviations

Dimension	Guided Group (mm)	Freehand Group (mm)
Mesiodistal	0.75 ± 0.2	1.5 ± 0.4
Buccolingual	0.5 ± 0.1	1.2 ± 0.3
Apicocoronal	0.3 ± 0.1	0.8 ± 0.2

Mean implant placement deviations were significantly lower in the guided group compared to the freehand group in all dimensions ($p < 0.05$). This indicates that guided implant placement resulted in more precise positioning of implants relative to the planned trajectories.

The results of this study demonstrate the superior accuracy of guided implant placement compared to freehand techniques. The guided group exhibited smaller deviations from the planned implant positions in both the mesiodistal, buccolingual, and apicocoronal dimensions. This highlights the effectiveness of utilizing surgical guides based on CBCT data to achieve predictable and precise implant placement. These findings are consistent with previous studies that have reported the advantages of guided implant surgery in enhancing accuracy and minimizing surgical errors (1, 2). By providing clinicians with a predefined trajectory for implant placement, surgical guides help to overcome anatomical limitations and ensure optimal implant positioning.

Discussion

The findings of this study underscore the significant advantages of guided implant placement over traditional freehand techniques, as evidenced by the superior accuracy achieved in the guided group.

The use of surgical guides based on CBCT imaging facilitated precise implant positioning, resulting in

smaller deviations from the planned trajectories compared to freehand placement.The superior accuracy of guided implant placement can be attributed to several factors. First, CBCT imaging provides detailed three-dimensional information about the implant site, allowing for thorough preoperative assessment of bone morphology, density, and adjacent anatomical structures [1]. This comprehensive evaluation enables clinicians to identify potential challenges and plan optimal implant trajectories to achieve favorable clinical outcomes.

Additionally, the use of surgical guides ensures reproducibility and consistency in implant placement, minimizing the variability inherent in freehand techniques [2]. By providing clinicians with a predefined trajectory for implant placement, surgical guides help overcome anatomical limitations and ensure precise positioning relative to the planned treatment plan [3].

This level of precision is particularly crucial in cases involving esthetic zones or limited bone volume, where even minor deviations can have significant implications for treatment outcomes. The clinical implications of these findings are substantial, as precise implant placement is essential for long-term success and stability of dental implants [4]. Accurate positioning minimizes the risk of complications such as implant malpositioning, nerve injury, and esthetic compromise, leading to improved patient satisfaction and prosthetic outcomes [5].

Despite the clear benefits of guided implant placement demonstrated in this study, several limitations should be considered. Firstly, the study design was limited to an in vitro setting, which may not fully replicate the complexities of clinical practice. Further research involving larger sample sizes and prospective clinical trials is warranted to validate these findings in a real-world setting. Additionally, factors such as operator experience implant design, and surgical technique may influence implant placement accuracy and should be considered in future studies.

Conclusion

In conclusion, guided implant placement utilizing CBCT imaging and surgical guides offers superior accuracy compared to freehand techniques. The precise positioning of implants achieved through guided surgery has the potential to enhance treatment outcomes and patient satisfaction in implant dentistry.

As technology continues to advance, guided implant placement is poised to become the standard of care for ensuring predictable and successful implant therapy.

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