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GUIDED IMPLANT SURGERY

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ABSTRACT

Guided implant surgery has revolutionized the field of dental implantology by offering precise and predictable outcomes while minimizing patient discomfort and reducing surgical time. This technique relies on advanced computer-aided design and manufacturing (CAD/CAM) technologies to plan and execute implant placement with unprecedented accuracy. One crucial aspect of guided implant surgery is the fabrication of surgical guides, which serve as templates to precisely position implants according to the preoperative plan. Among various types of surgical guides, those utilizing the concept of flapless, or minimally invasive, surgery have gained significant popularity due to their ability to streamline the surgical process and enhance patient satisfaction.

KEYWORDS: Guided implant surgery, precision, Steps involved in guided implant surgery, Surgical guides, Dynamic navigation system, Virtual treatment planning, Advantages and Limitations of guided implant surgery.

A. INTRODUCTION[1]

Guided implant surgery represents a revolutionary advancement in the field of dental implantology, providing precision and predictability in the placement of dental implants. This innovative technique involves the use of computer aided design and computer aided manufacturing technology to create a surgical guide to direct the exact positioning of dental implants in the oral cavity[1]. Guided implant surgery has gained popularity among dental practitioners due to its potential to enhance accuracy, efficiency, and overall treatment outcomes. The surgical guide, fabricated based on the virtual treatment plan serves as a template during the actual implant placement procedure. This guide ensures that the implants are inserted into the predetermined positions and angles, reducing the margin for error and improving the overall accuracy of the surgery. The use of guided implant surgery not only streamlines the procedure but also contributes to minimizing trauma to the surrounding tissues, potentially leading to faster healing times and improved patient comfort.[1]

B. OVERVIEW OF EVOLUTION OF GUIDED IMPLANT SURGERY

The evolution of guided implant surgery represents a significant advancement in the field of dental implantology. The development of this technique has been driven by advancements in technology, including imaging, computer aided design and manufacturing and a computer assisted surgery.[2]

It involves.

STEP 1: Pre implant planning by 3D radiographs.

STEP 2: Digital impression and prosthesis design using computer aided design / computer aided manufacturing (cad/cam) technology.

STEP 3: Guided surgery software facilitates virtual treatment planning with precision.

STEP 4: Stereolithographic guides are patient specific and aid in implant placement according to virtual treatment plan.

STEP 5: Real time navigation helps in intraoperative guidances during surgery, providing continuous feedback to ensure the surgeon follows the planned trajectory accurately.

STEP 6: Ongoing research has focused on developing biocompatible materials for surgical guides, ensuring patient safety and comfort during the procedure.

STEP 7: Post operative care of patient.

C. IMPORTANCE OF PRECISION IN IMPLANT PLACEMENT[1]

Precision in implant placement is crucial in guided implant surgery for several reasons. Guided implant surgery involves the use of computer-aided design (CAD) and computer-aided manufacturing (CAM) technologies to plan and execute the placement of dental implants. The importance of precision in this context includes.

ACCURACY IN TREATMENT PLANNING

- Precise implant placement starts with accurate treatment planning. Computer guided systems allow for detailed planning of implant position, taking into account the patient's anatomy, bone quality, and adjacent structures.
- Accurate planning ensures that the implant is placed in the optimal position for long term success, considering both esthetics and function.

AVOIDANCE OF VITAL STRUCTURES

- It is crucial to avoid damage to the vital structures such as nerves, blood vessels, adjacent tooth and adjacent soft tissue. Accurate planning and execution reduce the risk of complications and improve patient safety.

OPTIMAL ESTHETICS

- Precise implant placement is essential for achieving optimal esthetic outcomes. The position and angulation of the implant play a significant role in the final appearances of the restoration.
- Well placed implants contribute to a natural looking smile can help avoid complication such as unesthetic emergence profile.

ENHANCED LONG TERM STABILITY

- Precise placement ensures that the implant is anchored securely in the available bone, promoting long term stability. This is especially important for load bearing areas where the implant must withstand the forces of chewing and biting.

MINIMIZED SURGICAL TRAUMA

- Guided implant surgery often allows for minimally invasive procedures. Precise planning and placement reduces the need for extensive surgical procedures, leading to faster healing times and reduced postop discomfort.

IMPROVED PROSTHETIC FIT

- Accurate implant placement facilitates the fabrication of well fitting prosthetic restorations. Proper alignment and angulation of the implant facilitates proper fabrication of the prosthesis, which is efficiently functional and esthetic.

TIME EFFICIENCY

- Precise guided implants surgery can result in shorter chairside time for both dentist and patient. Reduced chairside time can contribute to increased patient comfort and satisfaction.

D. DIGITAL IMAGING IN GUIDED IMPANT SURGERY

Digital imaging plays a crucial role in guided implant surgery, providing detailed information for treatment planning, precise placement, and postoperative assessment.

CBCT[3]

- CBCT is a fundamental digital imaging modality in guided implant surgery. It provides three-dimensional images of the patient's oral and maxillofacial structures, offering a comprehensive view of bone volume, quality, and anatomical structures.
- High-resolution CBCT scans enable accurate treatment planning by allowing the clinician to visualize the patient's anatomy in detail

DIGITAL IMPRESSIONS[4]

- Digital impressions, often obtained using intraoral scanners, replace traditional, messy impression materials. These digital impressions provide a virtual model of the patient's dentition, aiding in the design of surgical guides and the fabrication of custom implant restorations

DIGITAL WAX UP[5]

- Digital surface scanning technologies capture the soft tissue contours of the patient's oral cavity. This information is essential for creating accurate surgical guides and designing prosthetic restorations that harmonize with the surrounding soft tissues

CAD[3]

- CAD software allows for the virtual planning of implant placement based on the information obtained from CBCT scans and digital impressions. Clinicians can manipulate virtual models to determine the optimal position, angulation, and depth for each implant.

SURGICAL GUIDE DESIGN[6]

- Digital imaging and CAD technologies enable the creation of surgical guides, which are precise templates used during surgery to guide the placement of implants. These guides are designed based on the patient's anatomy and the planned implant positions.

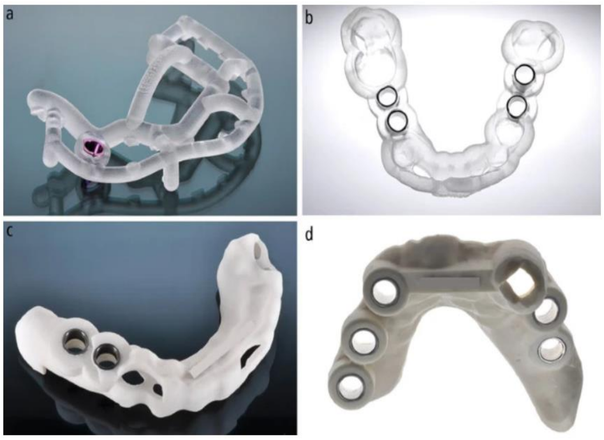

Figure 1.

Fig 1: a) Various surgical templates created by means of the polyjet technique (Smop; Swissmeda); b) the DLP technique (digital light processing; SHERAdigital); c) and SLS technique (selective laser sintering; EOS); d) as well as a subtractively manufactured (milled) surgical template.

DYNAMIC NAVIGATION

- Surgical navigation systems can track a surgical tool relative to the patient, and to dynamically position the surgical tool within the patient's pre-surgical computed tomography scan, updated in real time. There are two types of optical motion tracking systems: active and passive. Active tracking system arrays emit infrared light that is tracked to stereo cameras, and passive tracking system arrays use reflective spheres to reflect infrared light emitted from a light source back to a camera.[7] To begin with Scanning of the patient is done and is followed by software planning of the implant position is done. The next step is Image-to-patient registration via registration templates, external registration frames or bone markers. Then the surgery is begun using the navigation of the drill along the predefined surgical plan.[8]

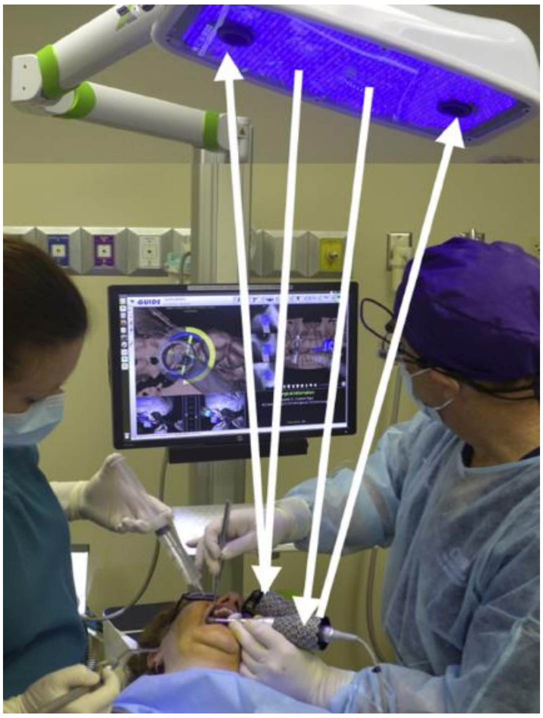

Figure 2.

Fig 2: Overhead lights emitting blue lights, which are reflected back to 2 cameras by the arrays on the clip in the patients mouth and on the handpiece.

IMPLANT SIZE AND ANGULATION ANALYSIS[1]

- Digital imaging allows for a detailed analysis of the available bone volume and density. This information helps in selecting the appropriate implant size and angulation to achieve optimal stability and long-term success

DIGITAL RADIOGRAPHY

- Digital radiography, including panoramic and periapical views, complements CBCT data by providing additional information about tooth roots, adjacent teeth, and the overall dental arch. This aids in comprehensive treatment planning.

POST OPERATIVE ASSESSMENT

- Digital imaging is valuable for postoperative assessment, allowing clinicians to evaluate the success of implant placement, osseointegration, and the overall health of the surrounding structures.

E. VIRTUAL TREATMENT PLANNING[10]

Virtual treatment planning in guided implant surgery involves the use of computer software and digital technologies to plan the placement of dental implants before the actual surgical procedure. This process enhances precision, allows for detailed analysis of patient anatomy, and facilitates the creation of surgical guides.

1. After patient assessment and scanning, data is transferred to CAD software where the models are virtually waxed up, carved and smile designing is performed.
2. Analysis of bone density and anatomy is a crucial step which is followed by virtual implant placement
3. After finalizing the position of implant virtually, surgical guides are fabricated using CAD software. These guides are 3D-printed or fabricated using computer-aided manufacturing (CAM) techniques. Surgical guides provide a template for accurate implant placement during the surgical procedure.
4. As patient acceptance is being important factor using the virtual treatment plan to educate and engage the patient plays a vital role. Visualizing the planned implant placement and the expected outcome helps patients understand the procedure, contributing to informed consent and increased satisfaction
5. Verify the accuracy of the virtual treatment plan and the designed surgical guide. Clinicians may make any necessary adjustments to optimize the fit and alignment of the guide based on the specific requirements of the case
6. Once satisfied with the virtual treatment plan and the surgical guide design, export the design file in a format compatible with 3D printing or computer-aided manufacturing (CAM) equipment. Common file formats include STL (Standard Tessellation Language) and others suitable for additive manufacturing.

F. EXECUTION OF TREATMENT PLAN FROM VIRTUAL TO REAL[11]

The transition from virtual treatment planning to the creation of surgical guides in guided implant surgery is the next step.

3 D PRINTNG / CAM FABRICATION

- Use 3D printing or CAM technology to manufacture the surgical guide. 3D printing is a common method for producing these guides, allowing for precise and customized fabrication. The guide is typically printed in a biocompatible resin or polymer.

PATIENT SPECIFIC ADAPTATIONS

- Some surgical guides may include patient-specific adaptations, such as the incorporation of fiducial markers or other features that enhance accuracy during the surgical procedure.

SURGICAL PROCEDURE

- After sterilizing the surgical guide the surgical procedure begins. Use the surgical guide to precisely position and angle the drills for implant placement. The guide serves as a template, guiding the clinician in following the pre-determined plan for optimal implant positioning.

POST OPERATIVE ASSESSMENT

- After implant placement, assess the outcome using postoperative imaging, such as CBCT scans. Verify the accuracy of implant placement and assess the initial stability of the implants.

G. ADVANTAGES OF GUIDED IMPLANT SURGERY[12]

Guided implant surgery offers several advantages compared to traditional implant placement method.

ENHANCED PRECISION

- One of the primary advantages of guided implant surgery is the level of precision it offers. Using advanced imaging technologies and computer-assisted planning, dentists can plan the exact position, angle, and depth of each implant before the surgery. This precision contributes to optimal implant placement and improves overall treatment outcomes.

MINIMALLY INVASIVE PROCEDURES

- Guided implant surgery is often minimally invasive, requiring smaller incisions compared to traditional implant placement procedures. This can result in less trauma to the surrounding tissues, reduced postoperative discomfort, and faster healing times for patients.

IMPROVED SAFETY

- The detailed preoperative planning in guided implant surgery helps identify and avoid vital structures such as nerves, blood vessels, and adjacent teeth. This significantly reduces the risk of intraoperative complications, enhancing the overall safety of the procedure.

EFFICIENT WORKFLOW

- The integration of digital technologies streamlines the treatment workflow. Virtual treatment planning, 3D printing of surgical guides, and computer-aided manufacturing (CAM) of restorations contribute to a more efficient process, reducing chairside time for both the clinician and the patient.

FASTER HEALING

- The minimally invasive nature of guided implant surgery, coupled with precise placement, often leads to faster healing and recovery times. Patients may experience less postoperative swelling and discomfort, allowing them to return to normal activities sooner.

ESTHETICS CONSIDERATIONS

- Guided implant surgery enables careful consideration of esthetic factors. Clinicians can plan the position and angulation of implants to achieve optimal esthetic outcomes, ensuring that the final restoration blends seamlessly with the surrounding dentition and soft tissues.

INCREASED PATIENT SATISFACTION

- The advantages of guided implant surgery, including reduced invasiveness, faster recovery, and predictable outcomes, contribute to increased patient satisfaction. Patients often appreciate the precision and efficiency of the procedure, as well as the potential for a more comfortable experience.

H. LIMITATIONS OF GUIDED IMPLANT SURGERY

There might be errors based on the accuracies of materials and types of equipment and techniques used for 3D printing of the surgical templates. Limited accessibility and availability of specific digital service provides another potential problem causing a delay in the treatment. The level of competency of the clinician in handling the guided implant surgery procedure is a crucial factor especially in completely edentulous arches.[13]

CONCLUSION

In conclusion, guided implant surgery represents a transformative approach to implant dentistry, leveraging advanced technologies to enhance precision, efficiency, and patient outcomes. The integration of cone beam computed tomography (CBCT), computer-aided design (CAD), 3D printing, and other digital tools has ushered in a new era of personalized and minimally invasive implant procedures.

The advantages of guided implant surgery are multifaceted. Enhanced precision in treatment planning allows for optimal implant positioning, reducing the risk of complications and promoting long-term success. Minimally invasive techniques contribute to quicker recovery times and increased patient comfort. The ability to customize treatment plans based on individual patient anatomy and esthetic considerations is a significant advancement.

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