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ADVANCED TECHNOLOGIES, AUGMENTED REALITY AND AI IN ORAL SURGERY: WHAT CAN WE DO NOW

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INTRODUCTION

Modern implant surgery has evolved from a two-dimesional (2D) planning approach, prone to inaccuracies, to a three-dimensional (3D) digital workflow. The latter ensures greater predictability and safety. The integration of Cone Beam Computed Tomography (CBCT), intraoral scanners (IOS), Artificial Intelligence (AI), and Augmented Reality (AR) is establishing a new standard of care. This approach allows for real-time visualization of critical anatomical structures, enabling more precise, minimally invasive surgeries with reduced recovery times for patients.

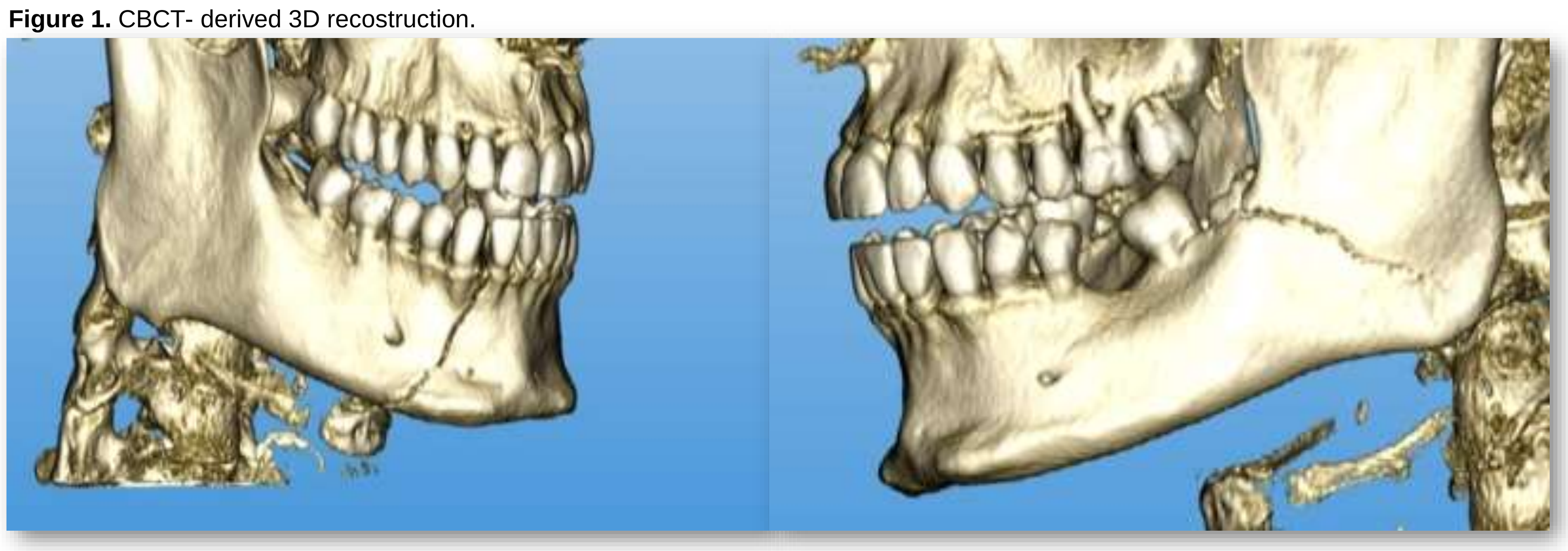
METHODS

The Integrated Digital Workflow

1. Data Acquisition and Virtual Patient:

CBCT for bone anatomy (DICOM format) and Intraoral Scanner (IOS) for soft tissues and arches (STL format).
Data fusion to create a complete 3D model of patient.

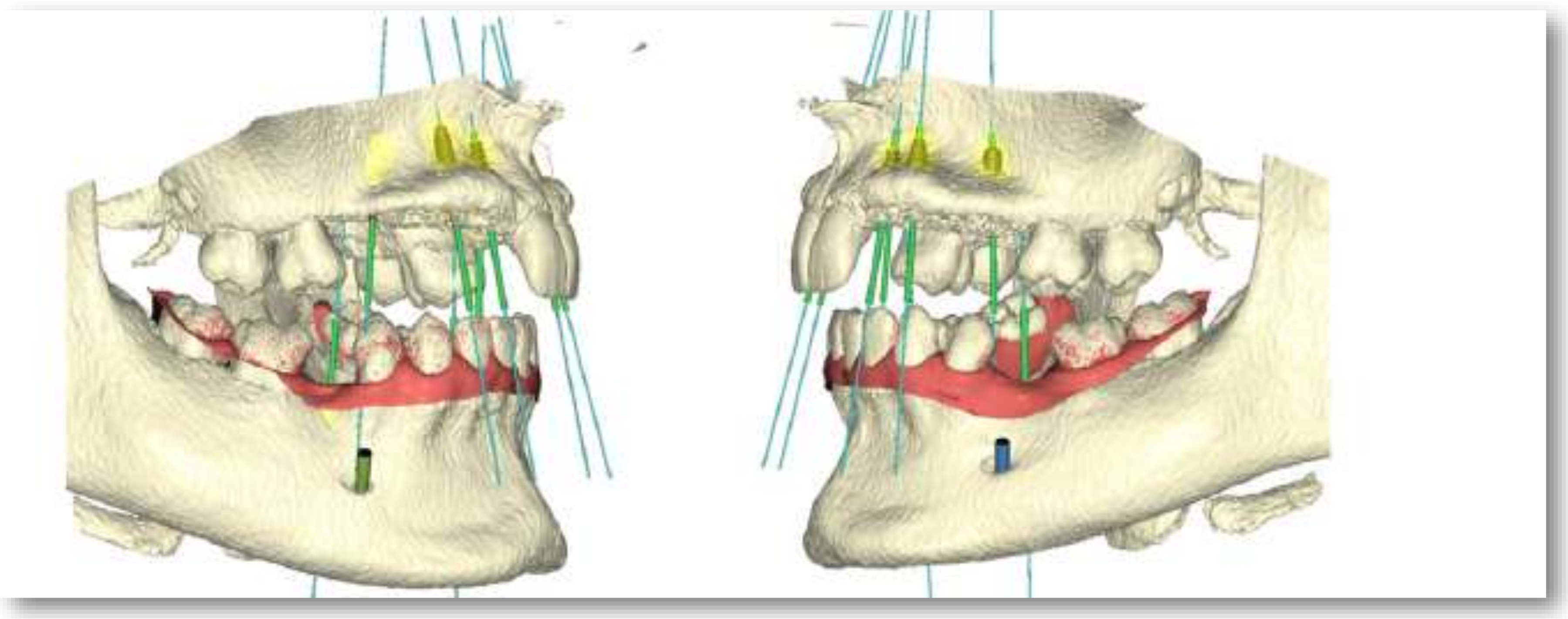
Figure 1. CBCT- derived 3D recostruction.



2. AI- Assisted Planning:

Dedicated software leverages AI for automated segmentation and visualization of critical anatomical structures.
Prosthetically driven virtual implant planning to determine the ideal implant position, angulation, and depth.

Figure.2. DTXStudio Implant simulation of implants.



3. Surgical Navigation with Augmented Reality (AR):

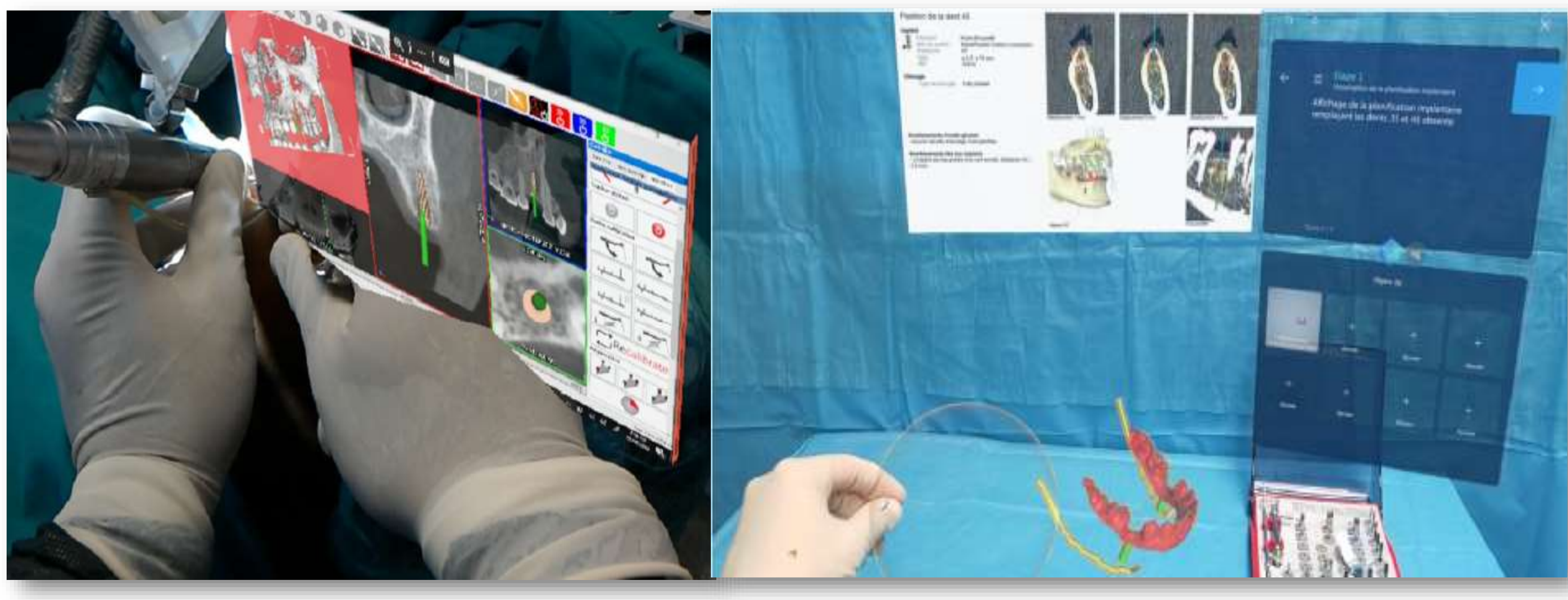
The surgical plan is imported into a head-mounted display (HMD).
AR HMDs fall into two principal categories:

- Optical See-Through (OST): e,g., Microsoft HoloLens;
- Video See-Through (VST): e.g., Visette 45 SXGA VST, Vuzix Wrap 920.

Figure 3. Types of AR HMDs: Microsoft HoloLens 2 , Vuzix Wrap 920 and Visette 45 SXGA VST.

The surgeon visualizes the 3D plan (implant axes, anatomical structures) overlaid in real time onto the operative field and performs a holographically guided freehand procedure.
This way you have a continuous visual guide.

Figure 4. The view of the surgeon during the surgery wearing Hololens glasses and Augmented reality surgical implant procedure checklist.



RESULTS

INCREASED ACCURACY	High accuracy, with mean apical deviations <1.6 mm and angular deviations < 5.5 °.
REDUCED OPERATIVE TIME	Significant reduction in surgical time compaed with 2D-guided methods.
ERGONIMICS AND SAFETY	Improved eye-hand coordination and enhanced safety via real- time visualization of anatomical structures.
REDUCED INVASIVENESS AND FASTER RECOVERY	Reduced surgical trauma due to more targeted procedures, facilitating faster postoperative recovery.
LIMITATIONS	High costs, a non-trivial learning curve, tracking sensitivity to lighting and motion, and HMD ergonomics that require improvement.

CONCLUSIONS

The integration of 3D imaging, AI, and augmented reality (AR) optimizes the entire implant workflow—from diagnosis through the surgical phase. Evidence shows that this approach achieves more accurate implant placement, reduces operative time, and enhances safety, particularly in managing critical anatomical structures. These benefits translate into less invasive procedures and, consequently, shorter postoperative recovery times, significantly improving patient outcomes.
Future prospects are oriented towards the use of increasingly accessible hardware and the need for further studies to validate and standardize clinical protocols.

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