3D Printing for Endodontic Applications With a Limited Budget

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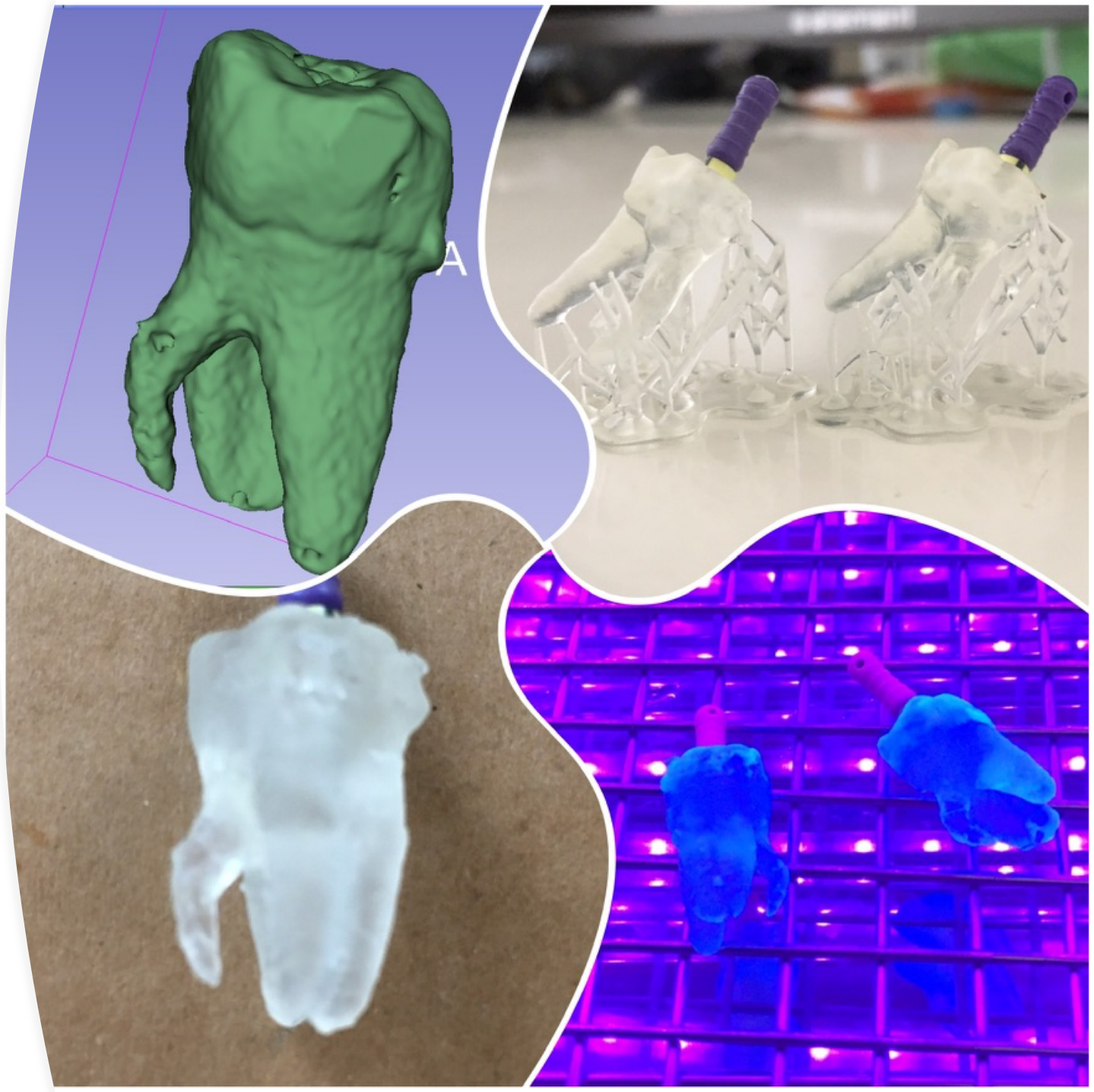
PIP Project Presentation

- Instead of presenting a completed endo case for this year's Excellence Day, I've decided to showcase the results of my PIP project that I've been researching and developing during this shelter in place.
- Due to the clinic shutdown during this time, most of the clinical applications demonstrated are based on actual patient cases that were completed prior to the shutdown.
- My hope is that the results from this project will help advance the use of 3D printing for our endo program and enable future residents to explore this further.



Introduction

- Since the advent of CADCAM (Computer Aided Designing Computer Aided Machining) in the 1960s, 3D printing has been implemented in many industries including the healthcare sectors. The use of 3D printing in reproducing anatomically accurate teaching resources in medicine has been explored and has also been implemented more widely in certain fields of dentistry such as oral surgery and prosthodontics. Within the recent years, it has started to gain more interest and implementation in the field of endodontics as well.
- Some of the main hindrances to the widespread adoption of this promising technology pertaining to endodontics could be 1) related to the cost and 2) the learning curve involved in learning the software, and hardware that is used.
- Most of the studies published with regards to endodontic applications have involved the use of higher end expensive 3D printers ($100,000 +) and expensive licensed commercial software.
- Nowadays, with the advent of newer budget 3D resin printers capable of higher accuracy/resolution and the widespread online availability of free open source software needed for 3D printing, adopting this technology into an endodontic practice is more feasible than before. This is further helped as more and more endodontists install their own CBCT machines/software into their clinics.

Goals of the Presentation

1) Demonstrate a proof of concept for a practical and feasible workflow to print 3D models of CBCT scans with a limited budget.

2) This workflow will be applied to a variety of different endodontic clinical applications. Possible clinical applications to be evaluated would include:

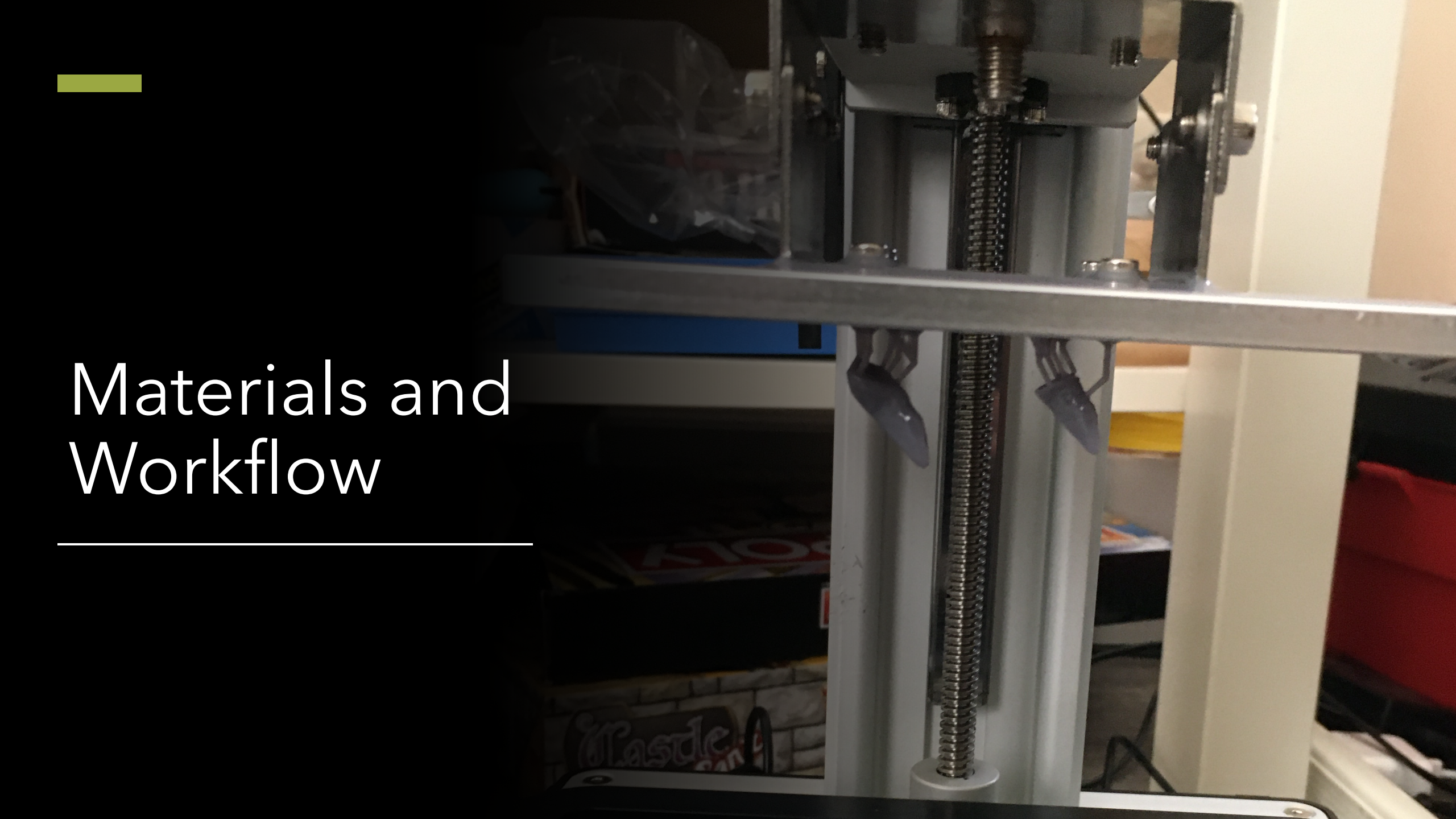
- Tooth replicas to study root anatomy and pathology prior to working on the patient
- Tooth replicas to aid in reimplantation/transplantion cases
- Tooth/jaw models to aid in treatment planning for apical surgery
- Patient education models tailored to each patient

Why Is This Relevant?

In a university setting, creating a reproducible and practical workflow can be very useful for training predocs/endodontic residents with regards to treatment planning and executing endodontic treatment, whether it be non surgical or surgical endo treatment.

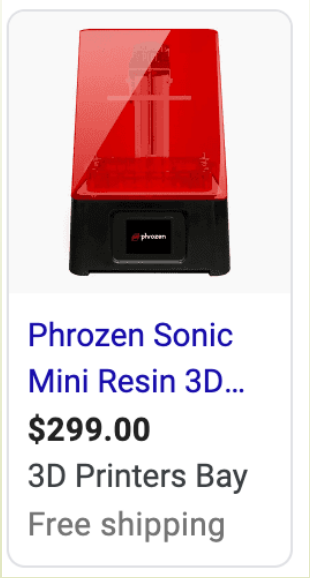
For endodontists in private practice who do not have access to higher end 3D printers or expensive 3D printing software, this can also be an affordable way to implement 3D printing technology into their own practices.

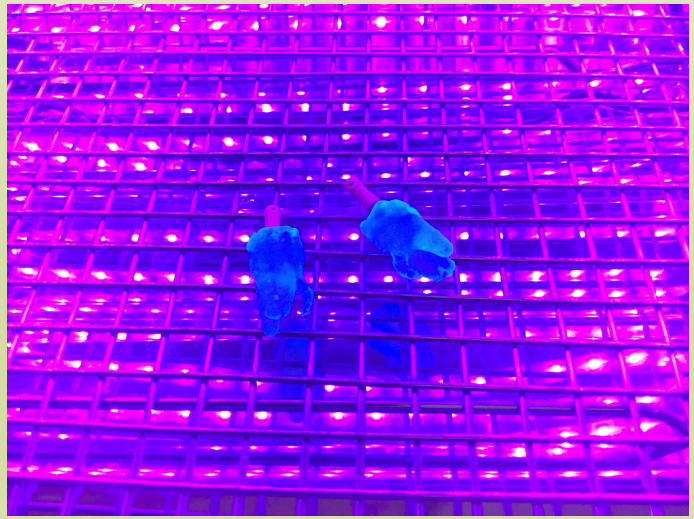
Materials and Workflow



Hardware Needed

- 3D Resin Printer- Phrozen Sonic Mini LCD 3D Printer ($300)
- Model Bath/Washing Station- (LOCK & LOCK HPL933BT Pickle Container)- $14
- UV Post Curing Station - (UV light strips + stainless steel bread basket + automatic timer + baker's rack) - $60
- Misc Items for Workflow- (Bottles of Resin for printing, IPA for washing, Nitrile gloves, mask, goggles, metal and plastic scrapers, filters, wire cutters)

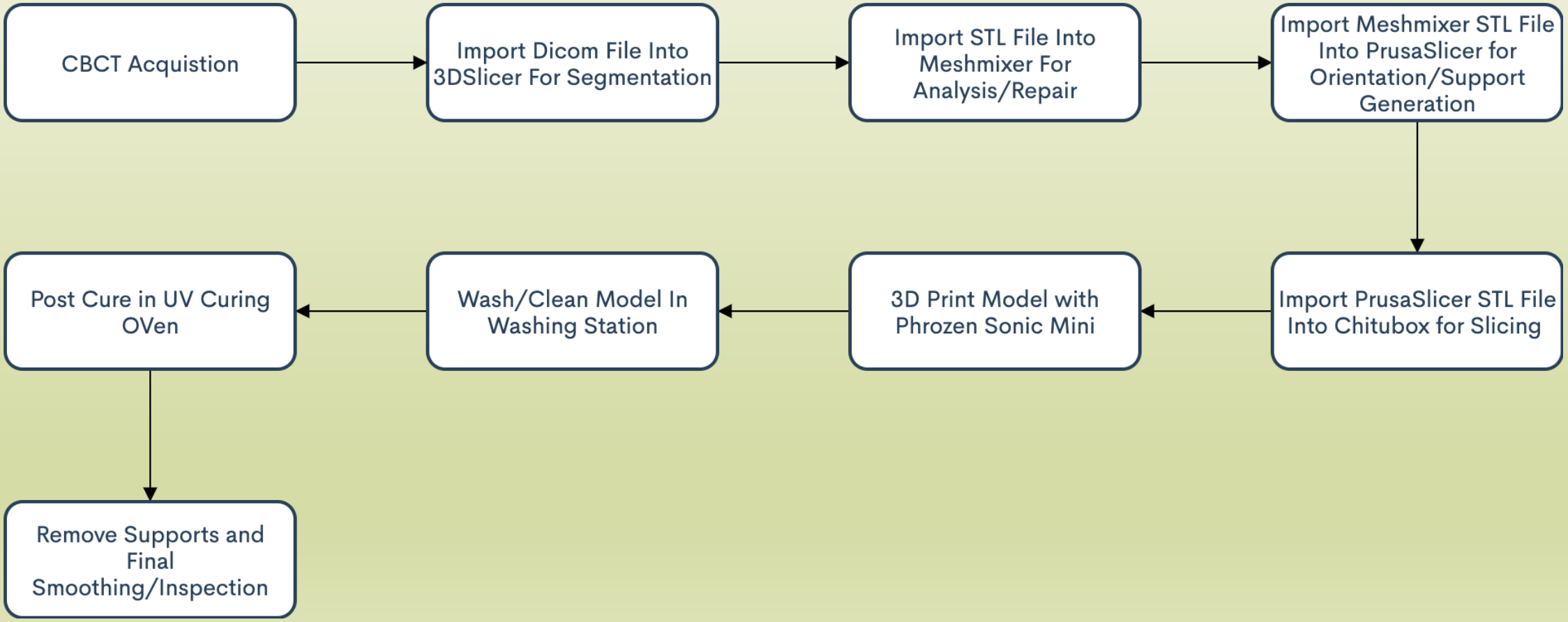




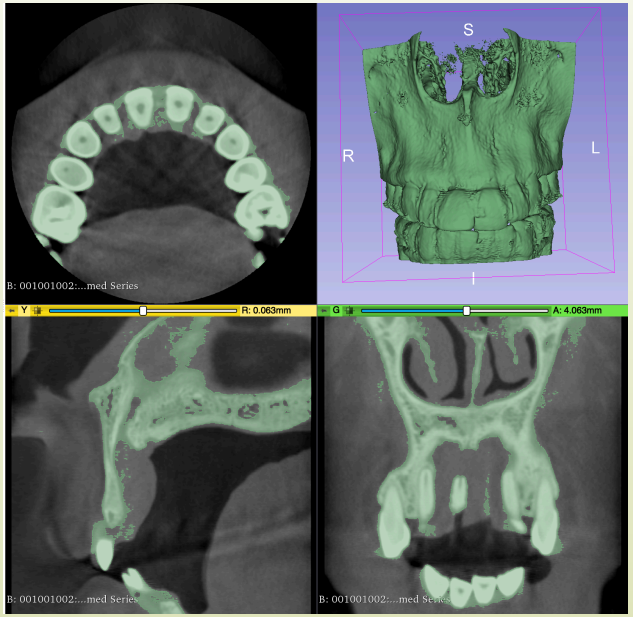
Software Needed

- For initial CBCT manipulation:
  3DSlicer- Free
- To analyze and correct model issues:
  Autodesk Meshmixer- Free
- To optimize orientation of model and generate supports:
  Prusa Slicer- Free
- To slice STL model for printing
  Chitubox- Free

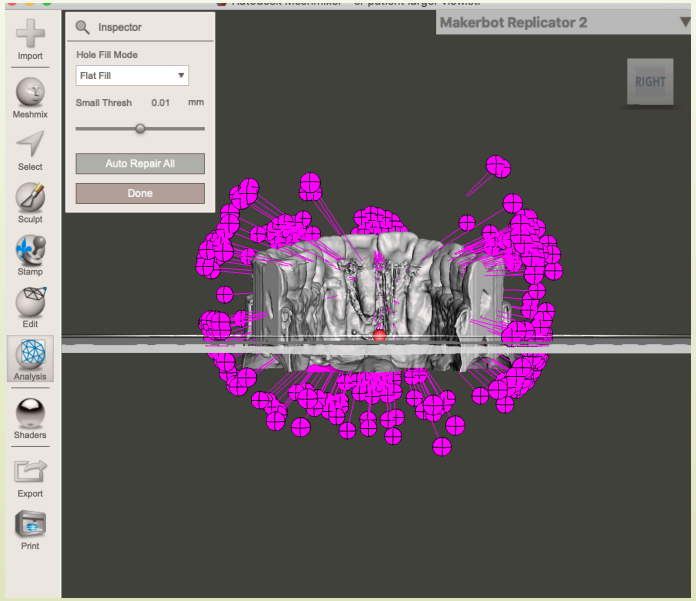
Workflow From Start to Finish



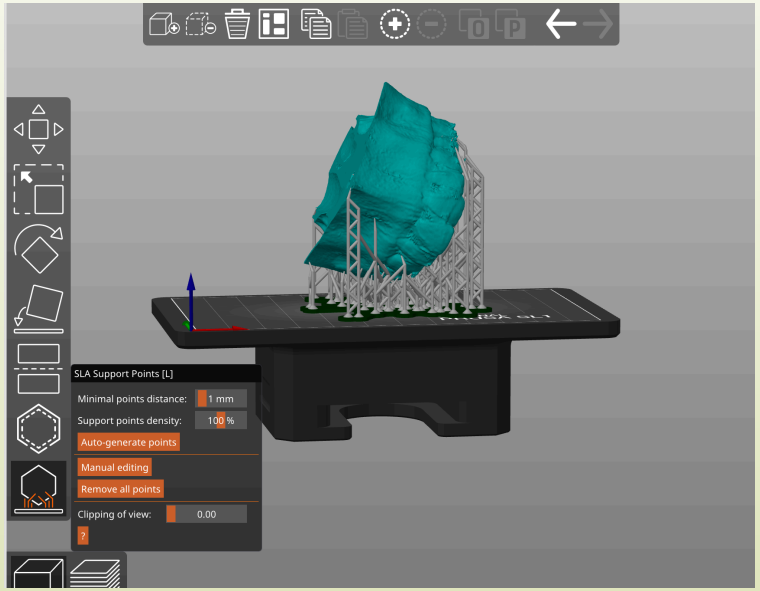
Design in 3DSlicer



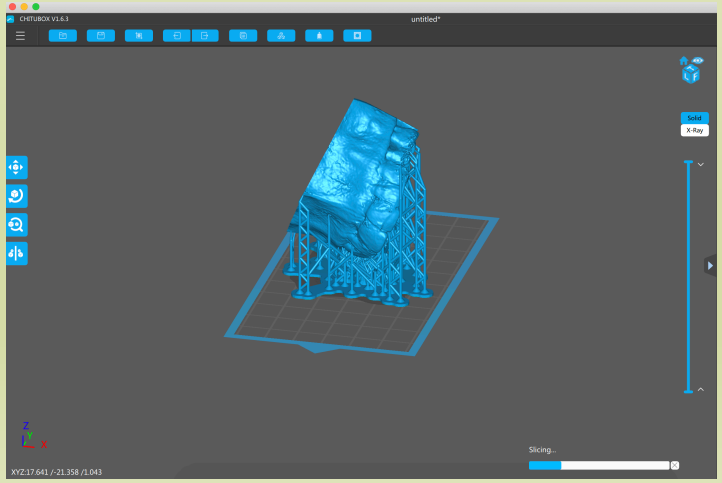
Repair in Meshmixer



Generate Supports in PrusaSlicer

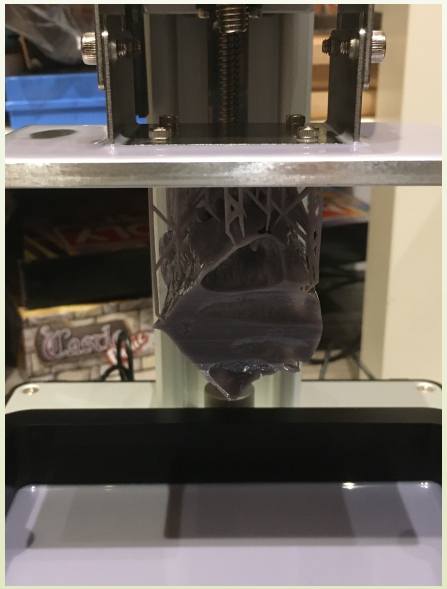


Slice File in ChituBox



Initiate Printing

After Print is Finished



Remove Print From Platform

Remove Excess Resin

Place in UV Curing Oven

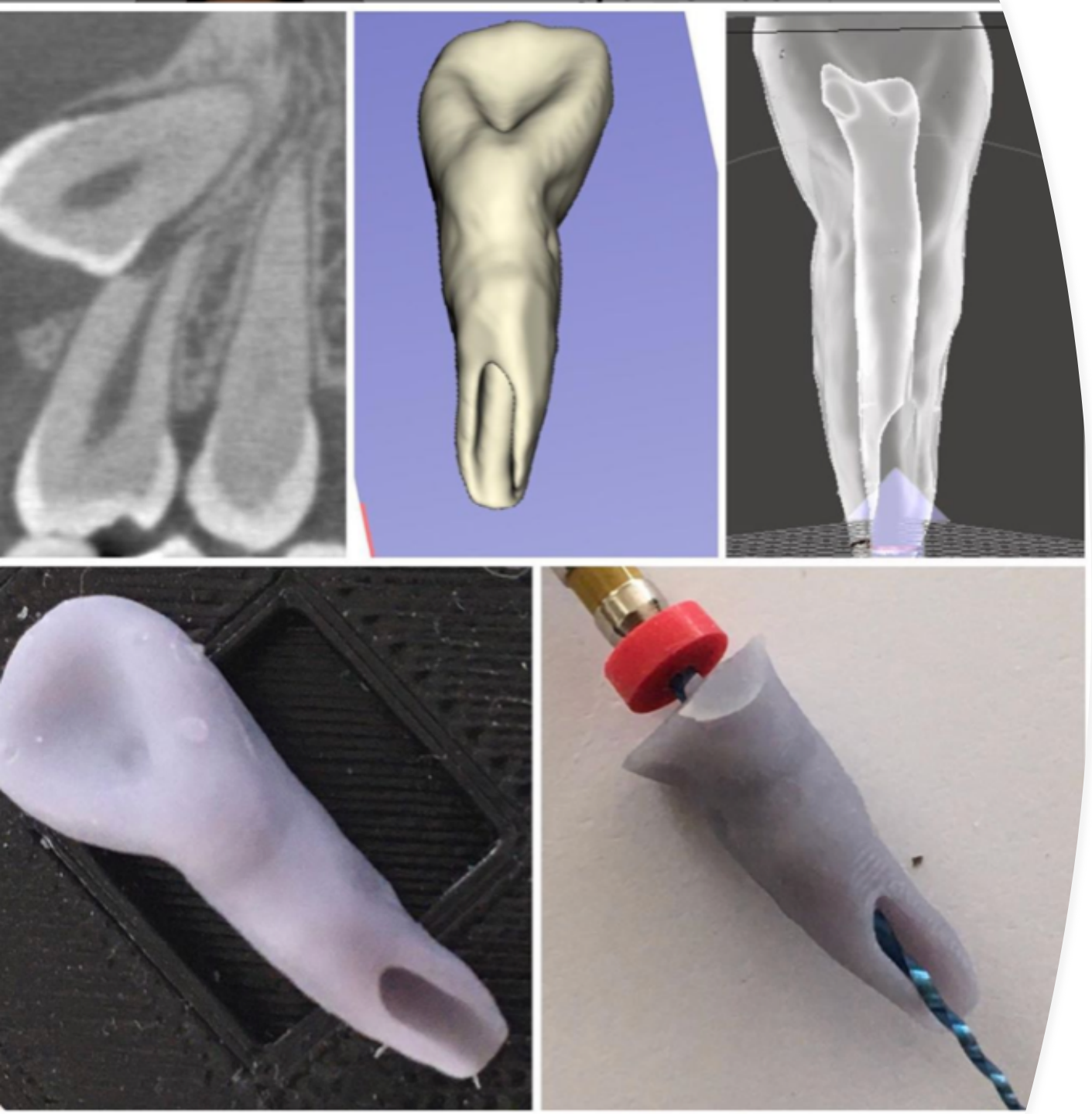
Cure For Time Indicated

Remove Supports

Final Inspection of Model

Clinical Applications

The following slides are some different clinical applications that have been tested with the proposed workflow.

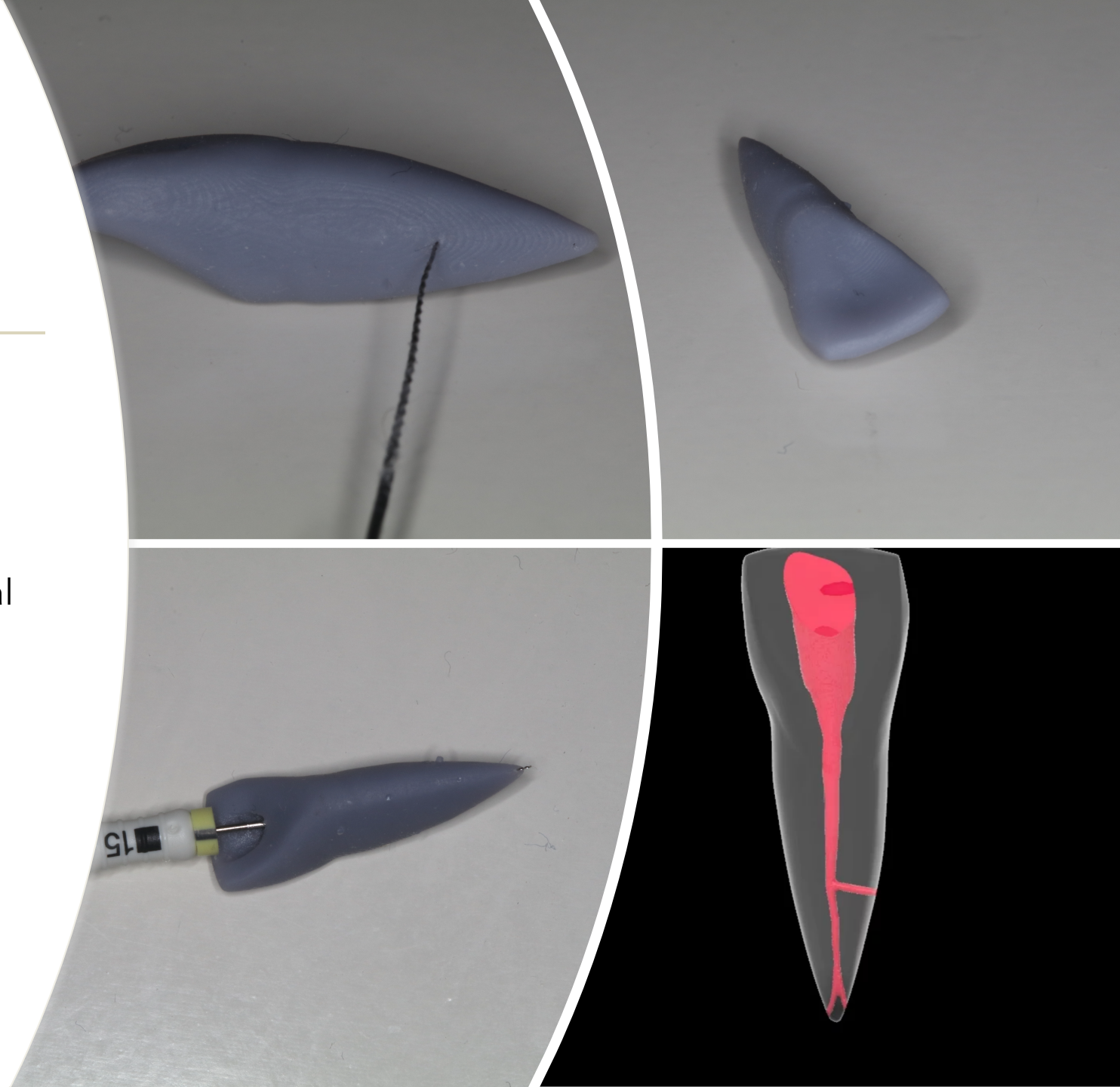


3D printing a tooth to assess the anatomy and deciding treatment plan

- 3D printed tooth #7 from CBCT of a 14 year old patient that I had completed regen tx on.
- Having the tooth beforehand would allow you to visually assess how wide the apex is and decide to proceed with regen or apexification.
- Also gives you the opportunity to practice your obturation technique with such a large apex.

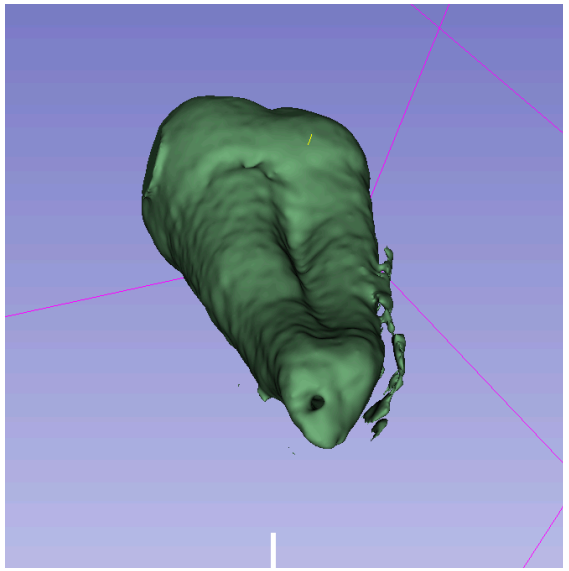
Practicing Access and Negotiating

- This is a STL model showing a high difficulty incisor case.
- Printing the tooth allows you to practice your access and negotiating prior to actual treatment.
- The 3D printed model was detailed enough that the lateral canal and two apical portals of exit were negotiable.



3D Replica of Lower Molar

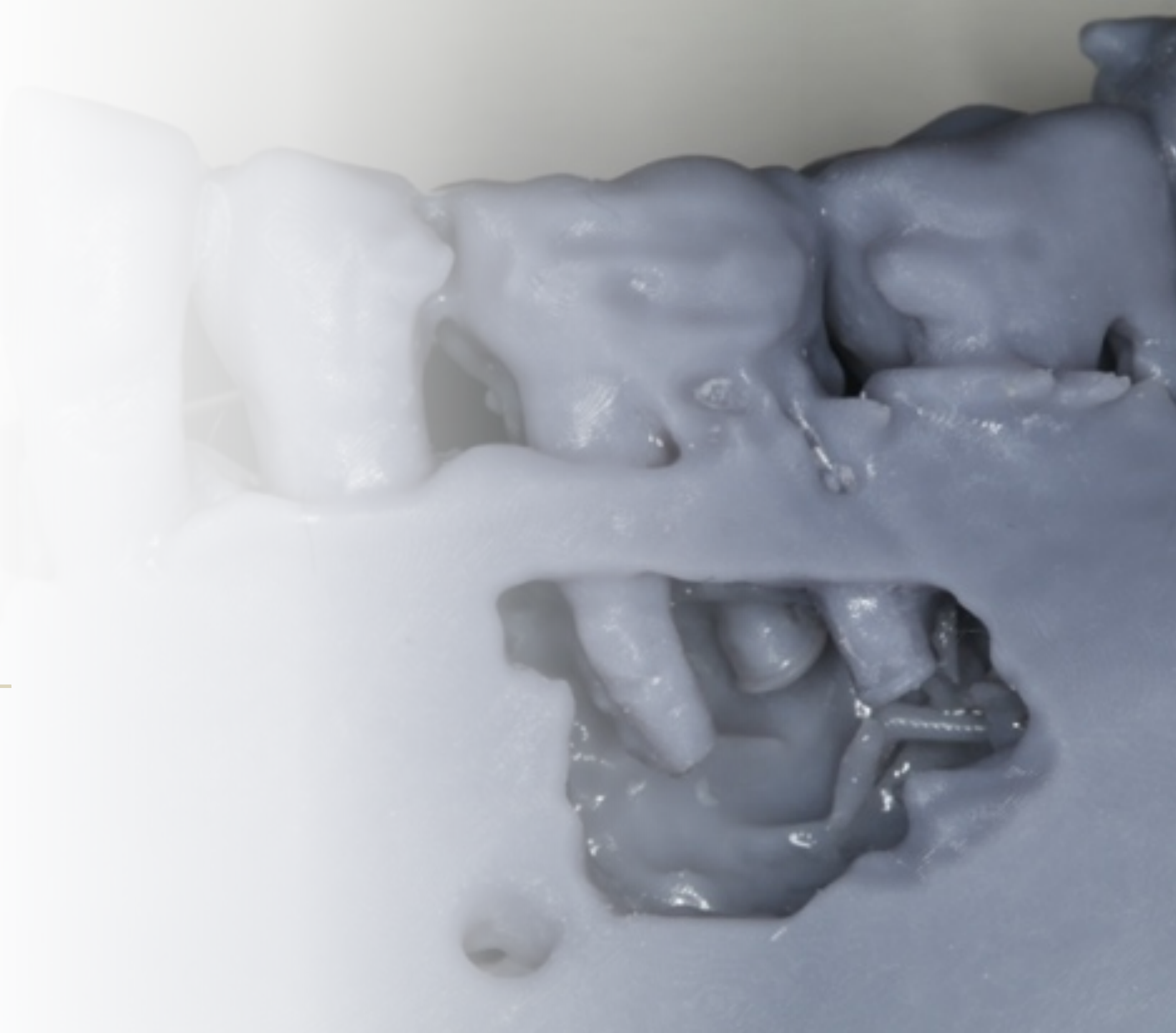
- This is a 3D replica of a tooth Dr. Serena Lee had completed treatment on.
- The internal anatomy was replicated so that the replica was negotiable with a hand file. With the 3D model, you can appreciate how the apical foramen exits short of the radiographic apex.



Radix Entomolaris

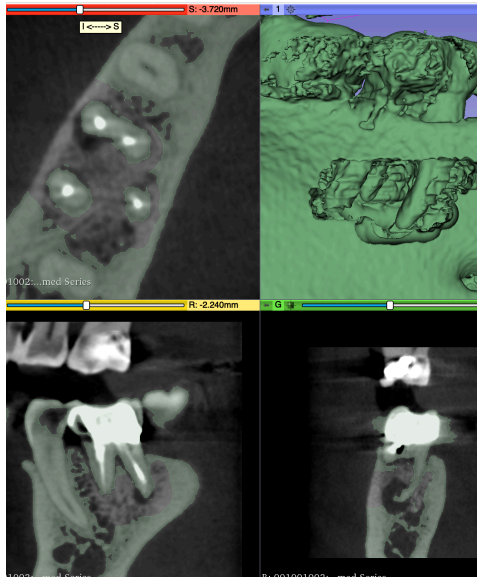
- Radix Entomolaris are notoriously known for the difficulty in cleaning and shaping the radix root due to the abrupt curvatures.
- 3D printing beforehand allows you to assess the curvature visually and determine the best way to shape and obturate the canal.

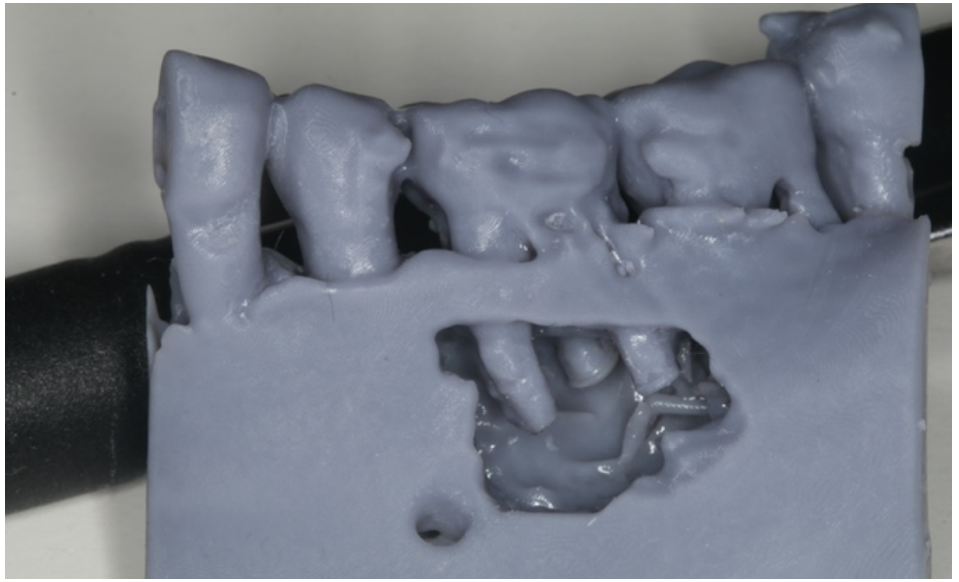
3D Printing For Surgical Evaluation



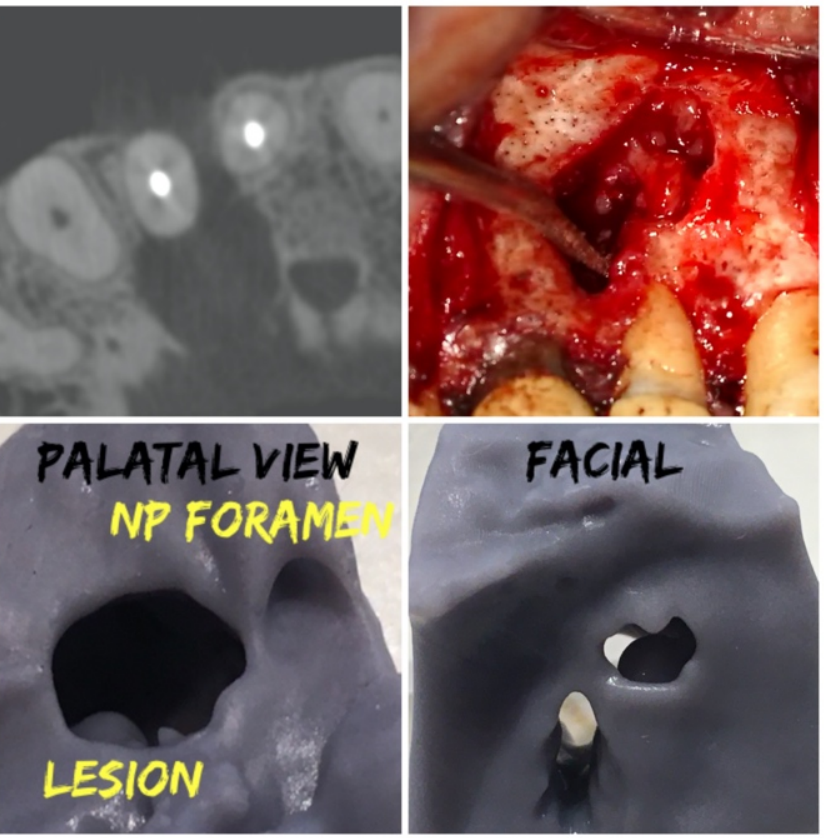
"Virtual" Osteotomy

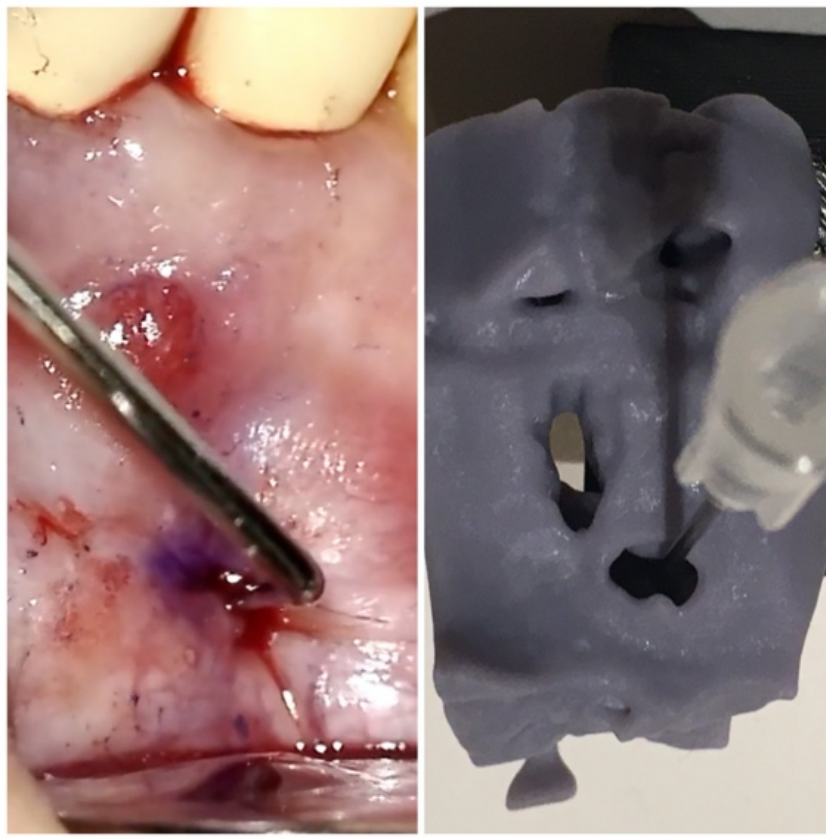
- This was a jaw model created to assess a patient who is being considered for apical surgery to address persistent lesions on the mesial and radix roots.
- A "virtual" osteotomy was done with software to remove the buccal bone and expose the roots.
- With the model, you can visualize how close the mental foramen is to the osteotomy site and also how difficult it would be to access the radix root.





3D Printing For Pathology Evaluation





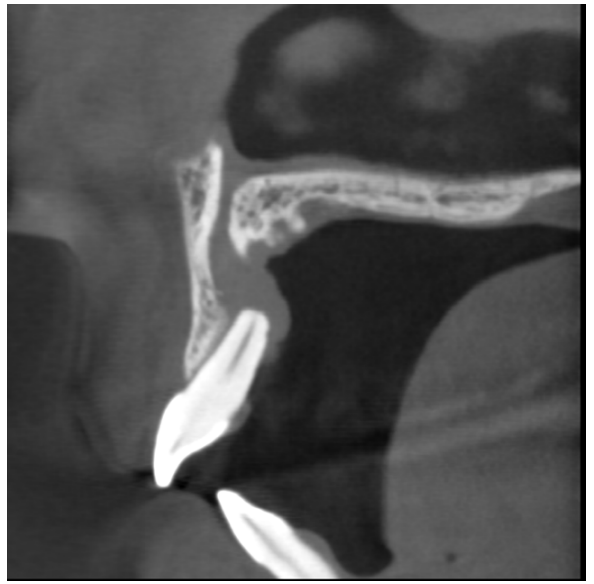
Assessing Extent of Periapical Pathology

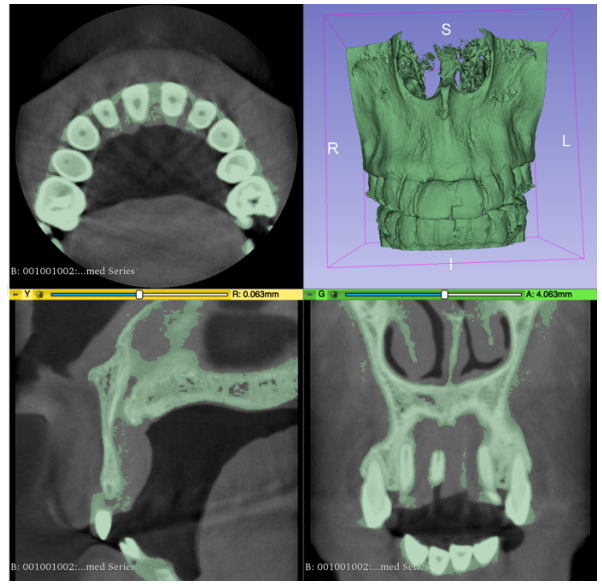
- This is a 3D model of a patient I had done decompression+apico surgery on to evaluate the buccal, and palatal extent of the lesion.
- Seeing the lesion in 3D allows you to better visualize the extent of buccal, palatal bone that is missing.
- Having the model would allow you to better plan the access and entry point for penetration when doing the decompression procedure.

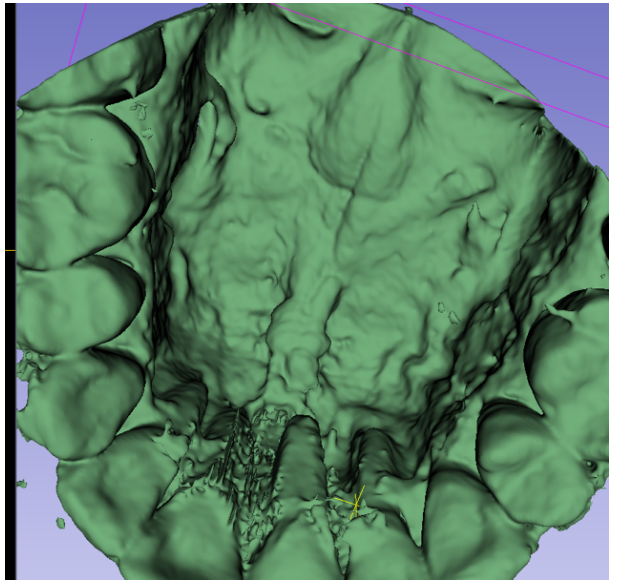
3D Printing For Patient Education

Maxillary Model Showing Extensive Bone Loss

- **This model of the maxilla was generated as a visual aid to show an ER patient how extensive the bone loss was on the palatal.**





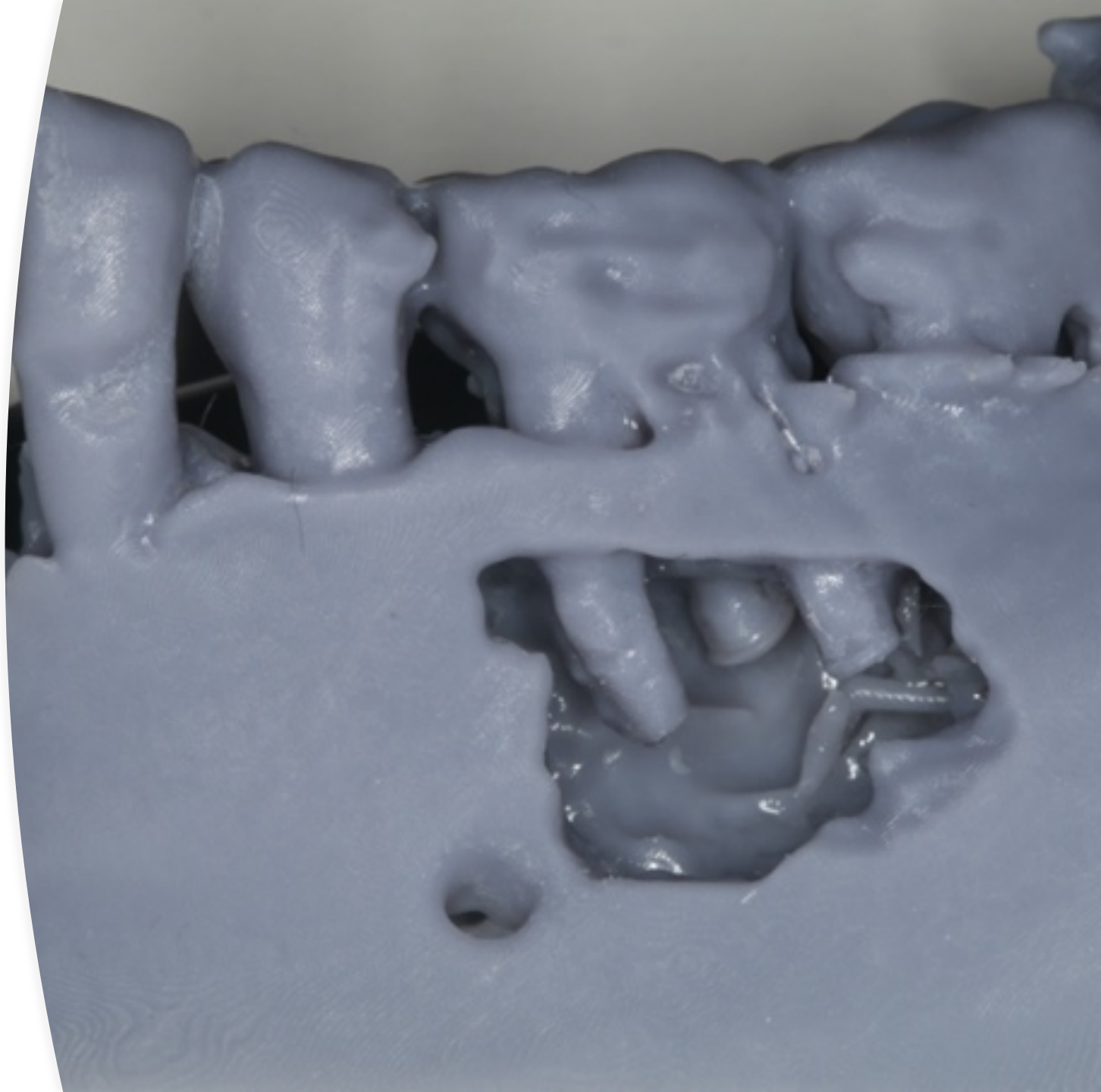


Model Showing Extensive Bone Loss

- Seeing the model, patient was better able to understand and accept why the long term prognosis of #8 is guarded.

Apico Surgery Patient Model

- With a model like this, you can visually show your patient the difficulty of doing apico surgery
- It also enables you to better explain the risks of paresthesia due to the proximity to the mental foramen by pointing it out.



What Does the Future Hold For 3D Printing at UOP?

- This proof of concept serves as a springboard for future residents to further explore avenues to implement this workflow in their treatment of endodontic patients.
- As technology improves in the future, hopefully the workflow can be modified and refined to make it more efficient and easy to use.

Thank You!