

Introduction

An important aspect of dental restoration procedures is ensuring that the patient is left with proper occlusion and evenly distributed loading across the jaw. Malocclusion can contribute to post-op sensitivity and discomfort for the patient, necessitating a return visit to the clinic. Return visits are inconvenient for patients, represent unpaid chair time for the clinic, and are especially undesirable during the COVID-19 pandemic. The current industry standard for evaluating occlusion is using articulating paper on the teeth, which the dentist interprets based on experience and theory.

Terminology

Articulating Paper: Inked paper used to create markings on teeth that represent contact intensity and location.

Cusp: Elevated point on crown of tooth.

Dental Restoration (Dental Filling): Treatment used to repair teeth, and restore function, integrity, and morphology of tooth.

Fossa: A shallow depression in tooth surface.

Occlusion: Refers to the contact surfaces of the teeth when the bite comes together.

Design Process

Problem Statement:

Design a device of procedural improvement to improve the reliability of occlusion adjustments to ultimately lower patients requiring follow up appointments.

Requirements:

Reduce repeat visits

Dental grade materials

Follow infection & contamination control guidelines

Stakeholder Engagement:

Talked to dentists to identify root issues and conducted research on practices from thought leaders in the area.

Design Concepts:

Plastic Barrier

Impression Mould

Image Analysis Tool

Final Design:

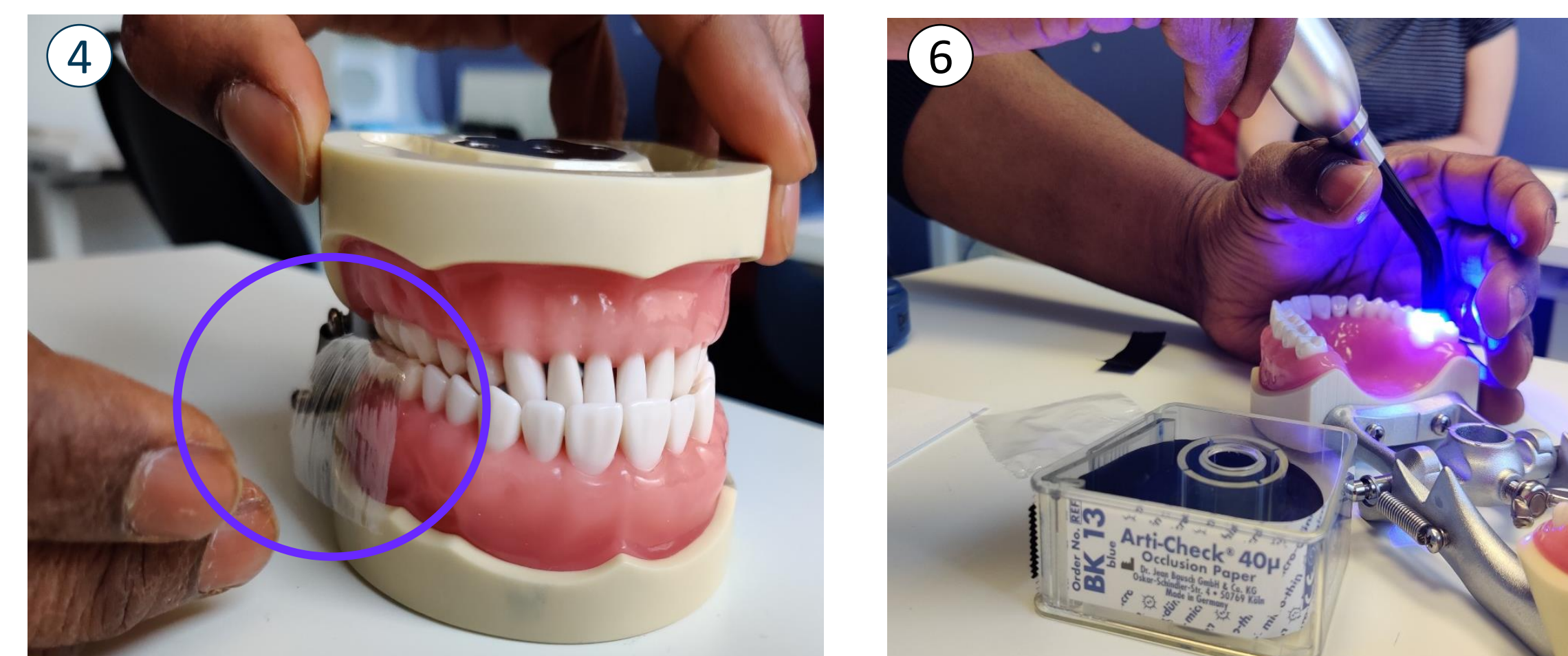
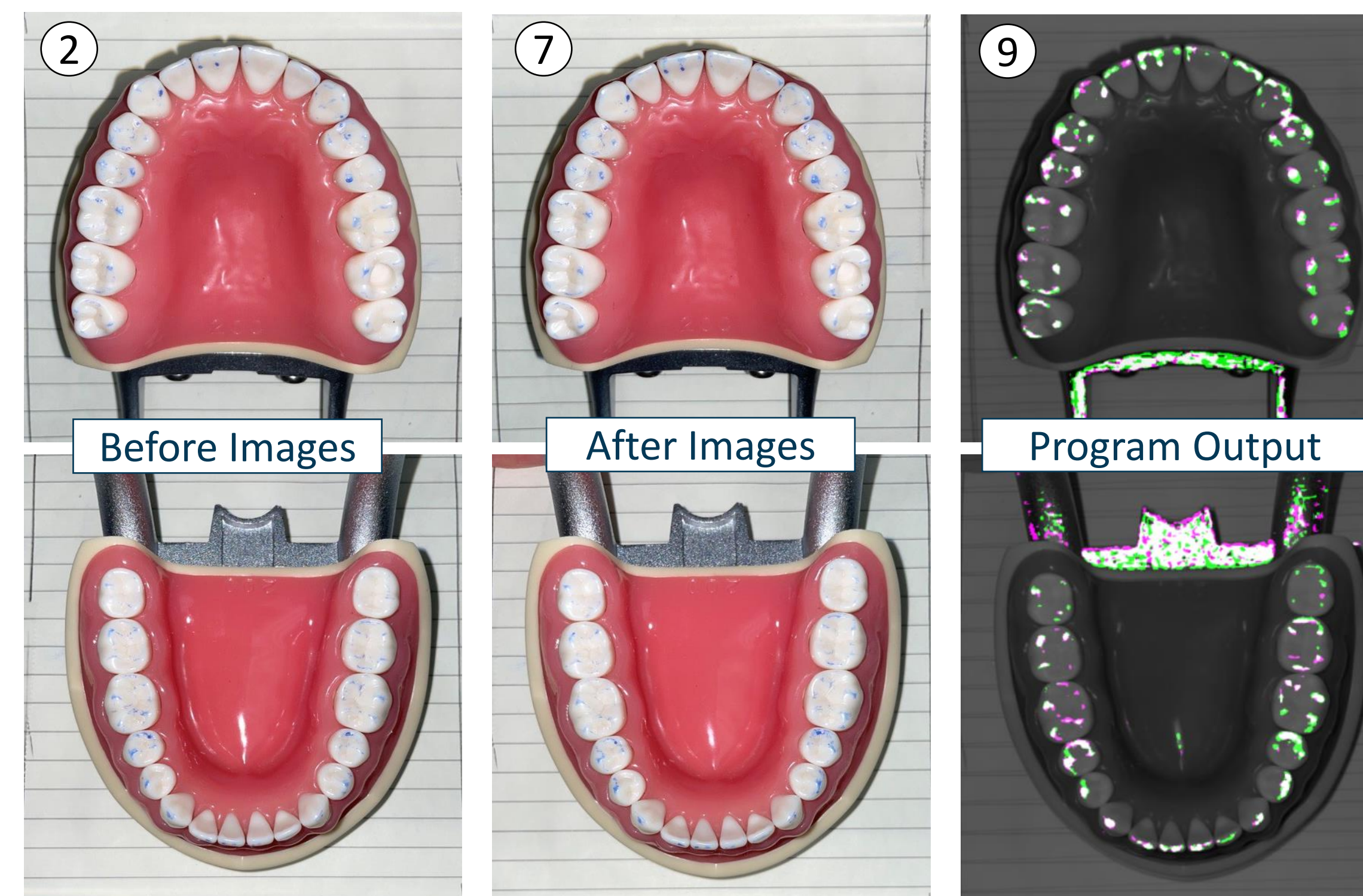
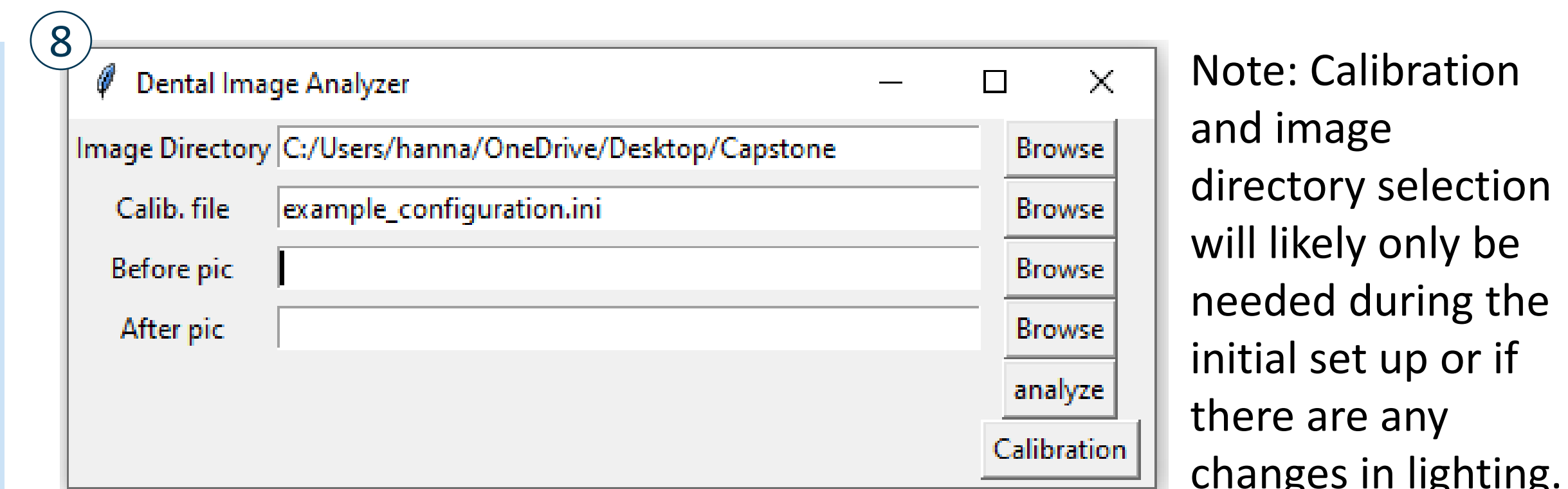
Pursued a combination of two ideas: plastic barrier method and image analysis software. Conducted testing to inform iterations before final design.

Details of Design

Procedure:

1. Prior to operation – mark teeth with articulating paper to identify the patient's initial occlusion and take "before" photo.
2. Upload image to operatory room computer.
3. Restoration conducted as normal, using packable filling material until application of final layer.
4. Plastic barrier will be placed over the teeth at the location of the restoration.
5. Patient closes bite which displaces excess filling material. Results in surface that fits the cusps of the opposing tooth (to replicate the original fossa).
6. Plastic barrier remains in place during light curing of final layer.
7. Markings done with articulating paper to obtain "after" photo.
8. Open and run Image Analysis application. User chooses their image directory, calibration file, and before and after images.
9. Click 'analyze' – application will then present a composite image of both the before and after image with the markings isolated and highlighted.
 - Markings only on the after image = green markings
 - From the before image = purple
 - Markings found on both images = white

This will inform the dental professional on how the post-op occlusion compares to the original occlusion and will inform them of where further material should be removed to achieve proper occlusal loading.



Conclusion and Recommendations

The accuracy of the current method of measuring occlusal loading following dental restoration procedures was increased through a process improvement and development of an image analysis tool. This program and updated technique can be used concurrently by dental clinics to reduce the subjectivity of occlusal adjustment procedures.

The image analysis software was designed to identify the differences between occlusal markings on the teeth before and after a restoration, providing a guide for the dentist when determining where to adjust. The tests done in the lab setting demonstrated that the software program could successfully highlight differences in markings, meaning that there is high potential for the software to be further developed and implemented in a clinical setting. The plastic barrier method was tested as well and resulted in closer agreement between the before and after sets of markings than what was found using the standard method.

Recommendations:

- Testing should be performed in a clinical setting, through collaboration with practicing dentists, to solicit feedback on the design and ensure that the program and barrier can be integrated into a standard practice.
- Quality of lighting and consistent orientation of imaging be emphasized to end users.

Testing

Flash Testing

- **WHY?** Lighting can have a large impact on the contrast.
- **HOW?** Took images of typodont with and without flash and compared the differences.
- **RESULTS?** Images with flash had more balanced lighting across teeth and allowed the code to better distinguish the markings.

Plastic Barrier Testing

- **WHY?** An important aspect of the plastic barrier method is the type of plastic being used.
- **HOW?** Compared results using the typodont with different thicknesses (0.014, 0.02, and 0.09 mm) of plastic as a barrier in laying the filling material.
- **RESULTS?** The thickest plastic (0.09 mm) was deemed unviable. The other two (0.014 and 0.02 mm) had satisfactory results.

Consistency Testing

- **WHY?** Interested in whether certain teeth have a higher chance of false markings. This information could be used in further iterations of the application.
- **HOW?** Had the same person mark the typodont with controlled technique and compare the overlaid images.
- **RESULTS?** Initial testing showed consistency across both the same person taking markings as well as across different people taking markings of the same typodont.

Real Person Testing

- **WHY?** While the typodont has been a useful tool in developing the concept and application, for market viability it is important that images of real teeth can be analyzed.
- **HOW?** Ran program with images of real teeth.
- **RESULTS?** Promising results, further testing using dental grade cameras is necessary.

References

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