Objective Assessment of Dental Anatomy Using Surface Scanning Technology and 3D Image Analysis

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Background & Rationale

- Dental students traditionally learn dental anatomy by making teeth out of wax to match human dentition on a plastic typodont.

- Student wax-ups are graded visually by trained dental school faculty.

- Dental students sometimes receive different feedback on the same project depending on the time and person grading.

- This traditional evaluation of wax-ups is time consuming, labor intensive, and subjective.

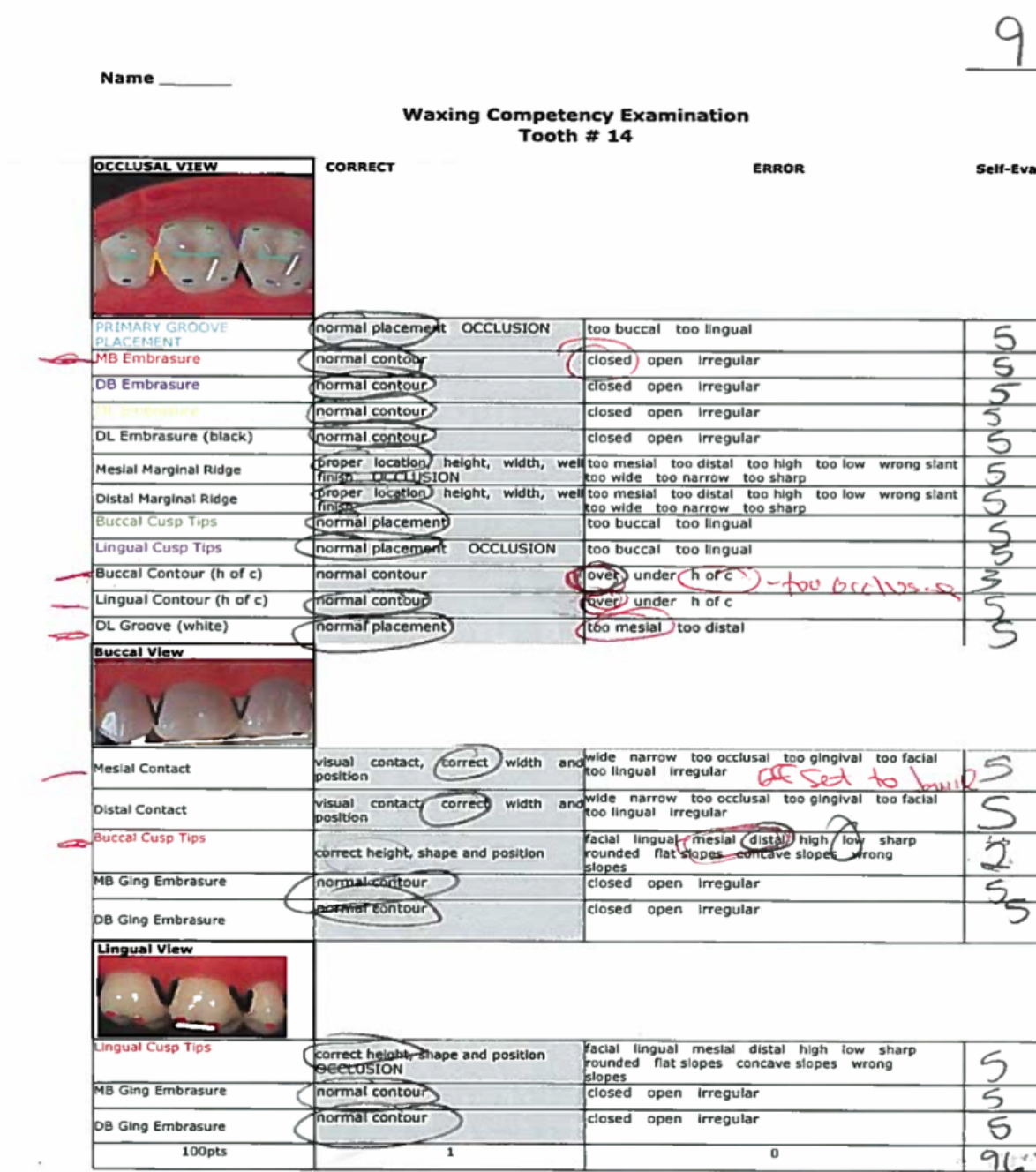**Figure 1.** Dental student wax-up on a typodont.

Figure 2. Grading rubric.

Rationale: New technology and research using intra-oral scanners provides an objective method for evaluation.
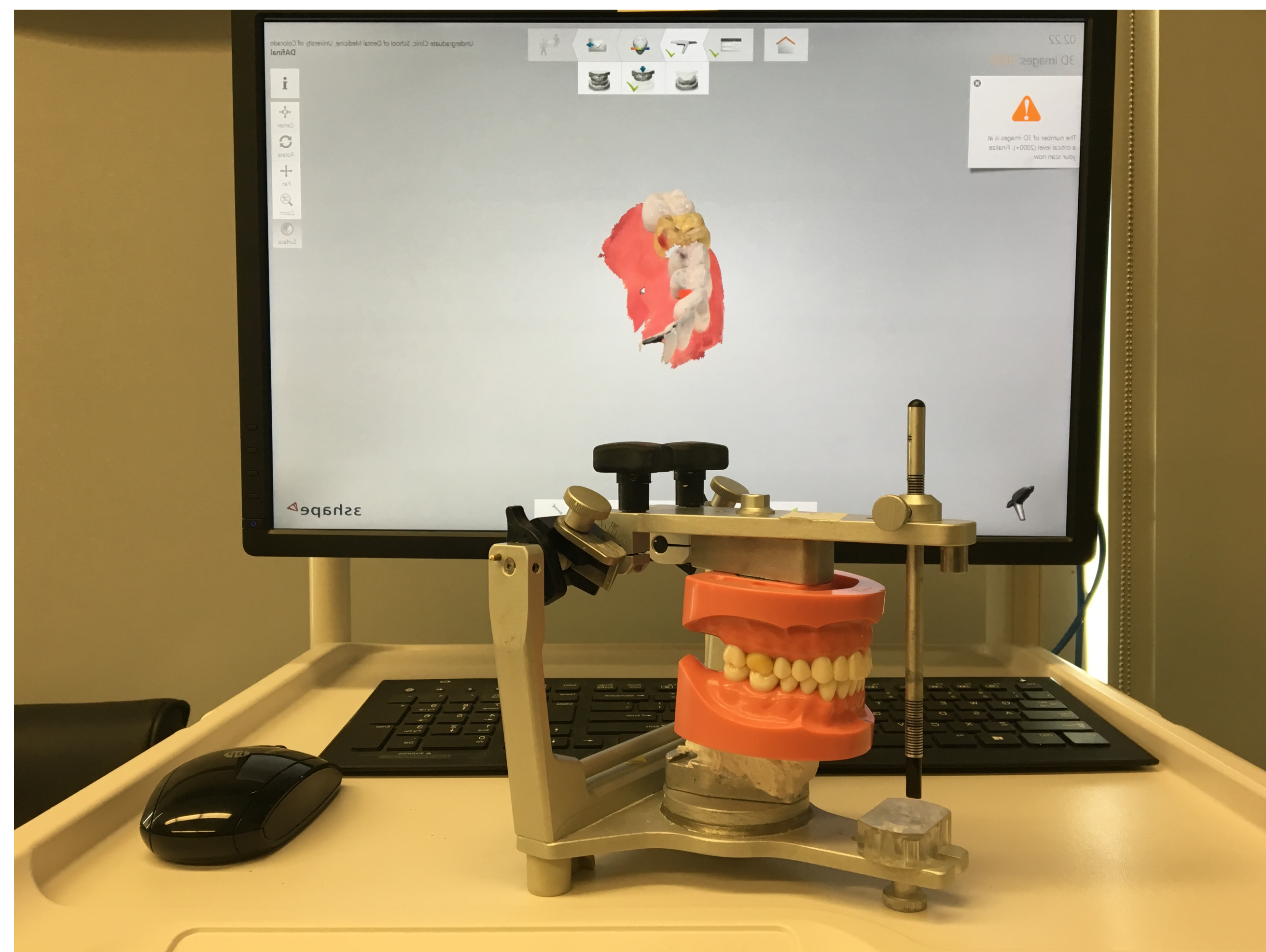

Figure 3. Student wax-up scanned into a virtual 3D model using the Trios 3Shape Scanner.

Methods

Goal of Study: Design a useful protocol for virtual evaluation and objective grading of student dental anatomy projects.

Hypothesis: Virtual evaluation provides more accurate and precise grading results than traditional visual grading.

Approach:

1. Scan ideal reference model and scan student wax-up (figure 4).
2. Import .STL models into CloudCompare software (figure 5).
3. Align models and measure differences between them (figure 6).
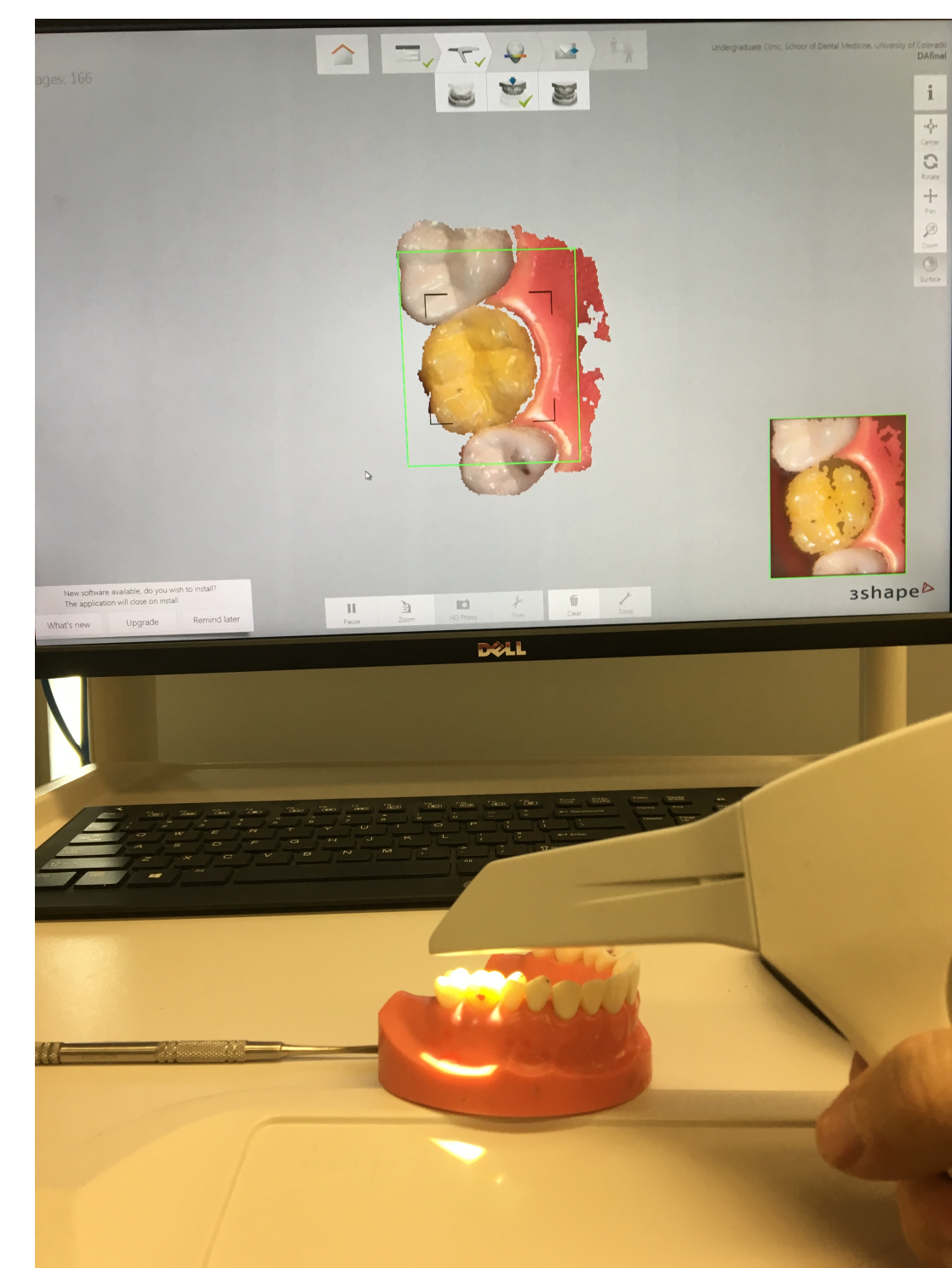4. Grade the wax-up projects traditionally and virtually (figures 2 & 7).

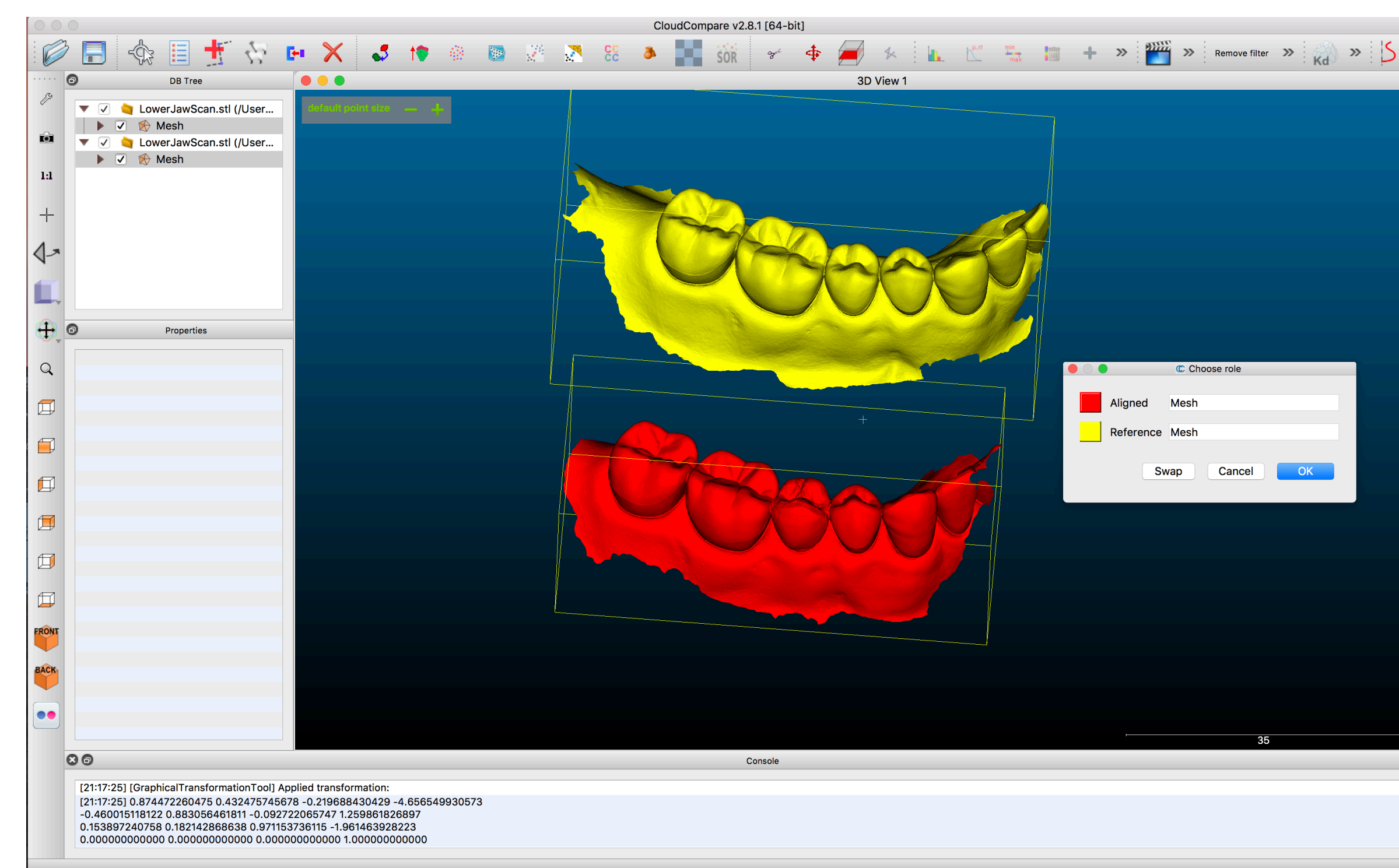**Figure 4.** Scanning models using the Trios 3Shape Scanner.

Figure 5. Stereolithography (.STL) models of a student wax-up (red) and ideal reference model (yellow) imported into CloudCompare software.
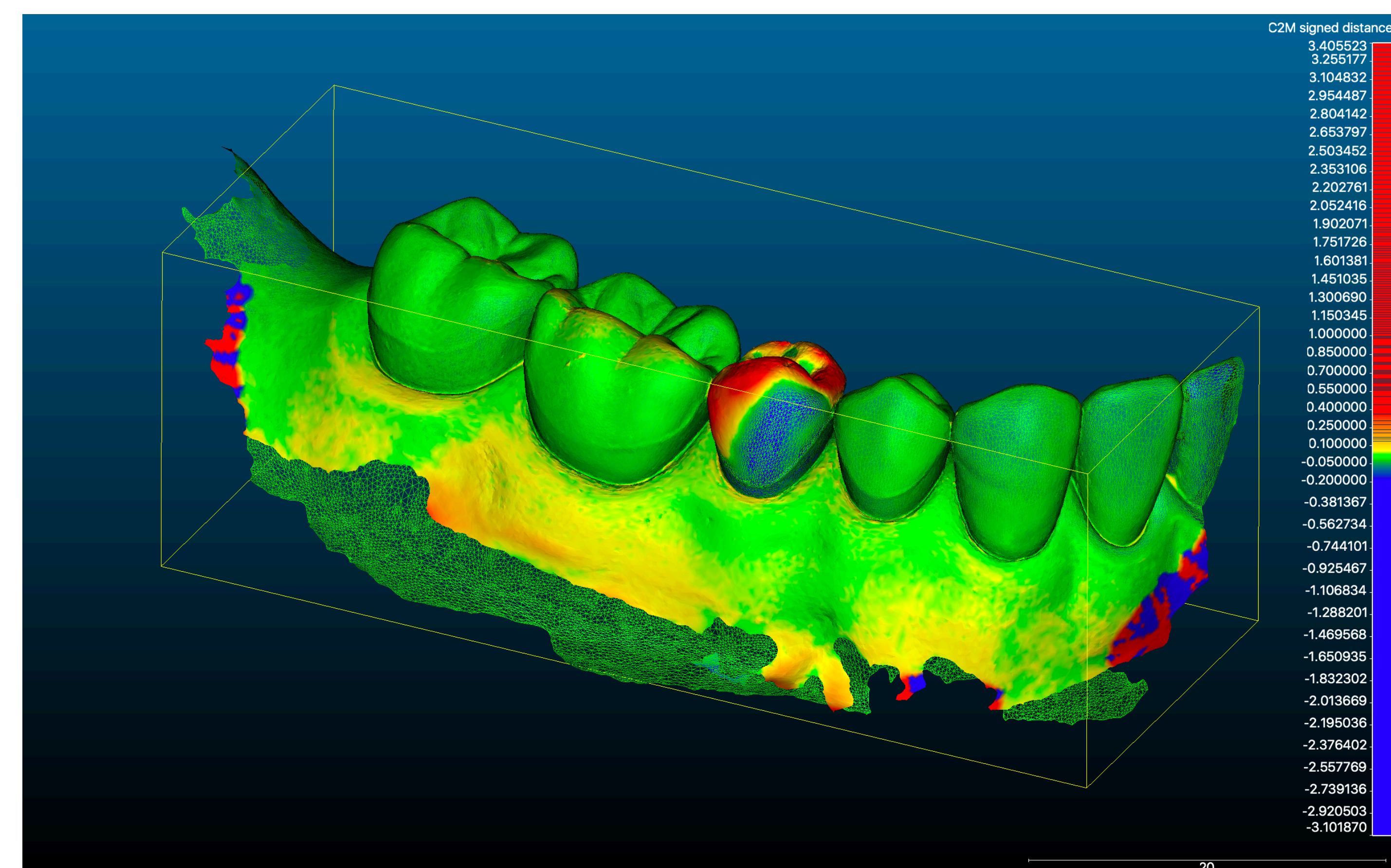

Figure 6. Student wax-up and ideal reference model aligned together. Blue represents under contour of the wax-up. Red represents over contour of the wax-up. Green represents alignment of the models within 0.05 millimeters. A scale bar in the lower right shows 20 millimeters.

Results

Intra-rater Reliability (Precision):

Table 1. Statistical analysis of faculty graders using traditional visual inspection.

Grader	Avg. Change	t-test p-value	Significant Difference
101	0.05%	0.45577	no
102	0.56%	0.30365	no
103	-4.65%	0.00328	yes
104	-5.17%	0.00194	yes
106	-1.53%	0.04006	yes

Changes in Grader Averages Between Sessions
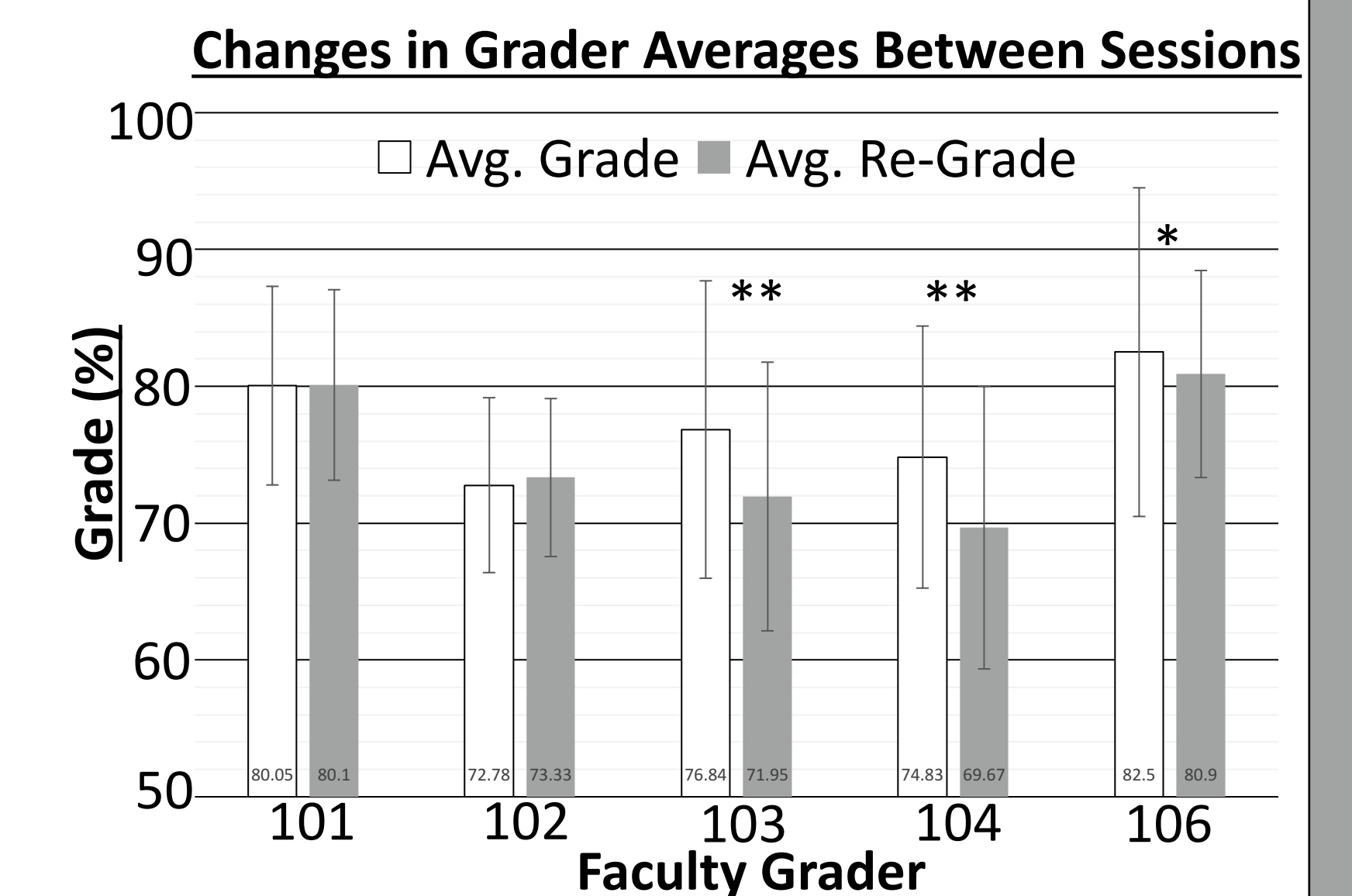
Inter-rater Reliability (Accuracy):

- Faculty Graders Intraclass Correlation Coefficient (ICC) = 0.332 (poor)

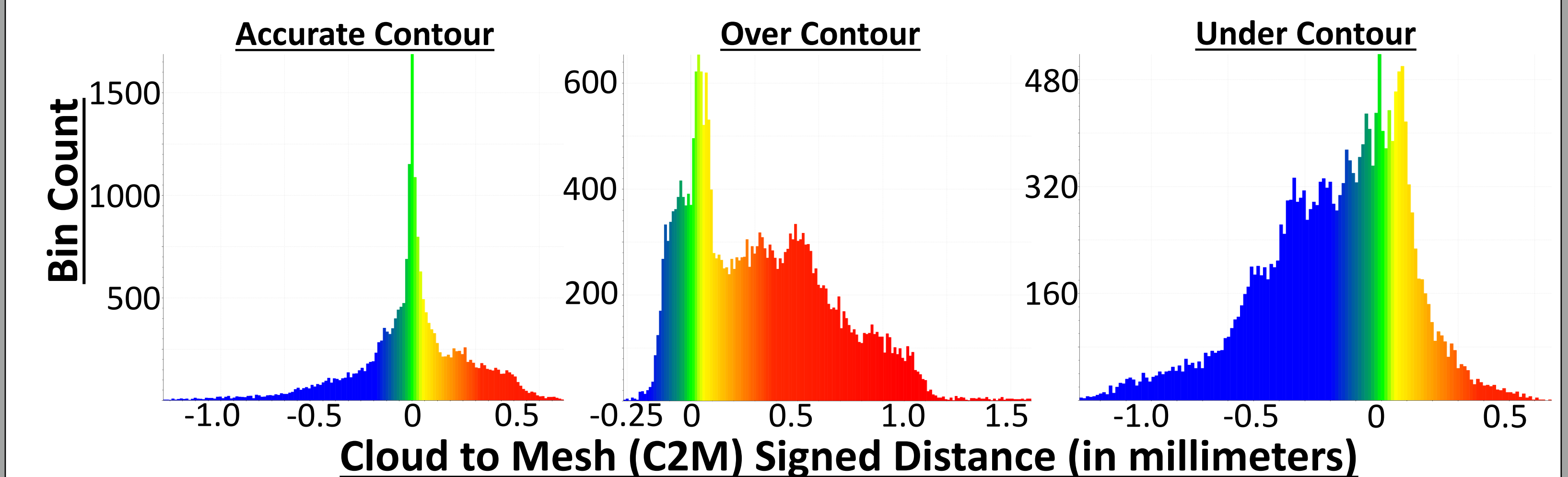- Digital Graders Intraclass Correlation Coefficient (ICC) = 0.866 (excellent)

Figure 7. Histogram data examples for an accurate wax-up (DA3), an over contoured wax-up (DA10), and an under contoured wax-up (DA41) using virtual evaluation.

Conclusions

- Traditional visual inspection lacks precision.

- Virtual evaluation is more accurate than traditional visual grading.

- Virtual evaluation is faster, less labor intensive, and more objective than visual grading.

- New CloudCompare technique facilitates student self-assessment, enhanced teaching tools for faculty, and an improved protocol for grading dental anatomy projects.

Acknowledgements