

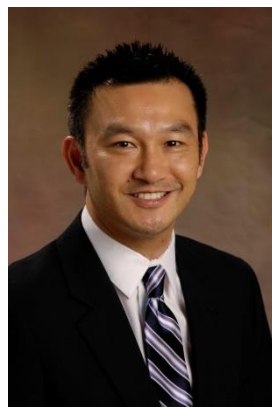


Consortium of Operative Dentistry Educators  
Annual Meeting. Chicago, IL  
February 23, 2017

# The Future of Teaching Clinical Simulation in the Virtual Reality



Sandra Farah-Franco



Brent Fung



Brian Chui

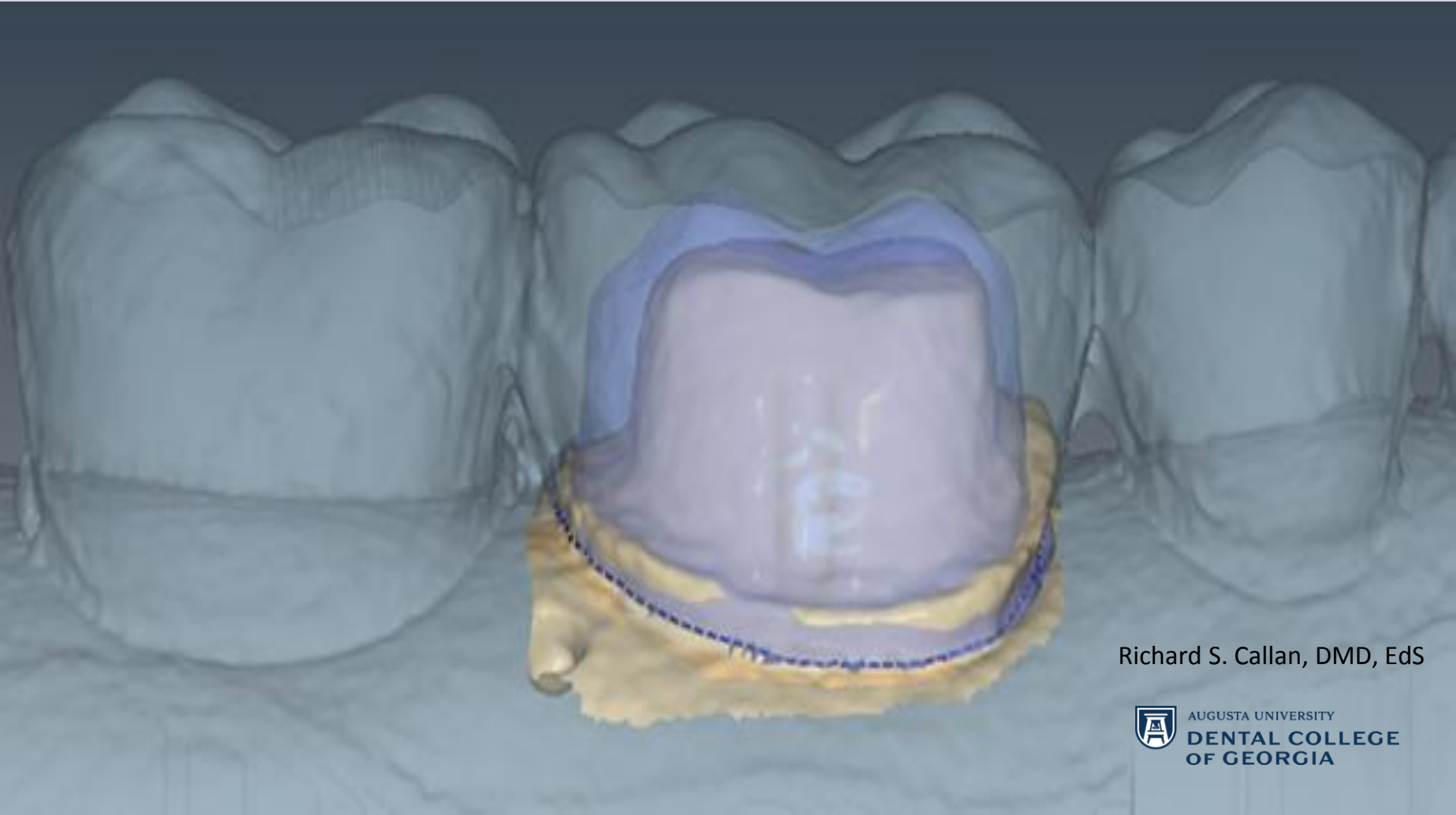


Robert Hasel



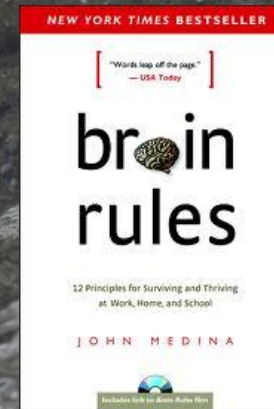
*The discipline of learning. The art of caring.*

*Creating a Grading Rubric Using EAD Compare and  
Faculty Assessment*

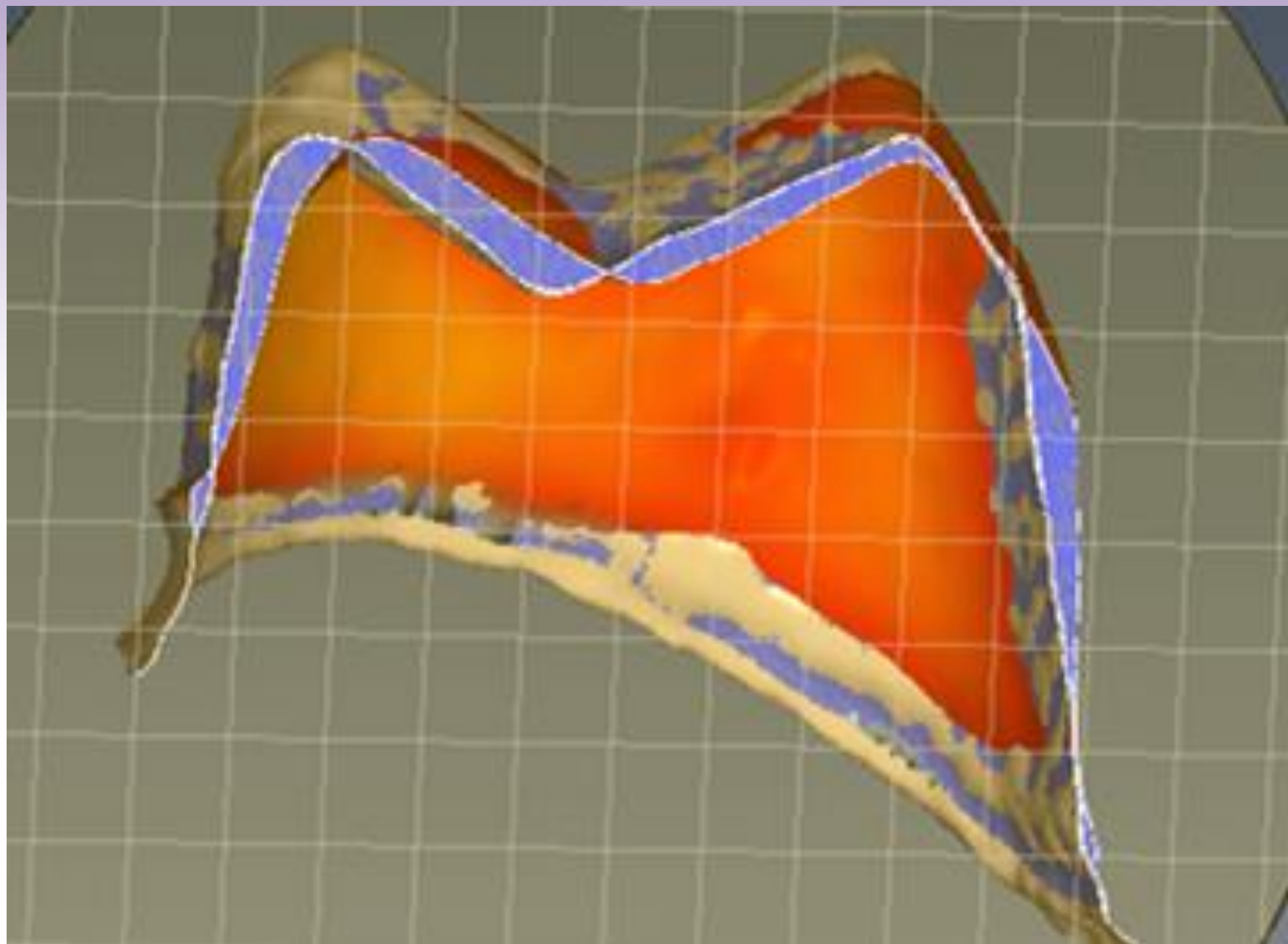


Richard S. Callan, DMD, EdS

*Rule 10: Vision trumps all other  
senses*







# Reliability of CAD CAM Technology in Assessing Crown Preparations in a Preclinical Dental School Environment

Richard S. Callan, D.M.D., Ed.S.; John S. Blalock, D.M.D., Ed.S.; Jeril R. Cooper, D.M.D.; John F. Coleman, D.M.D.; Stephen W. Looney, Ph.D.

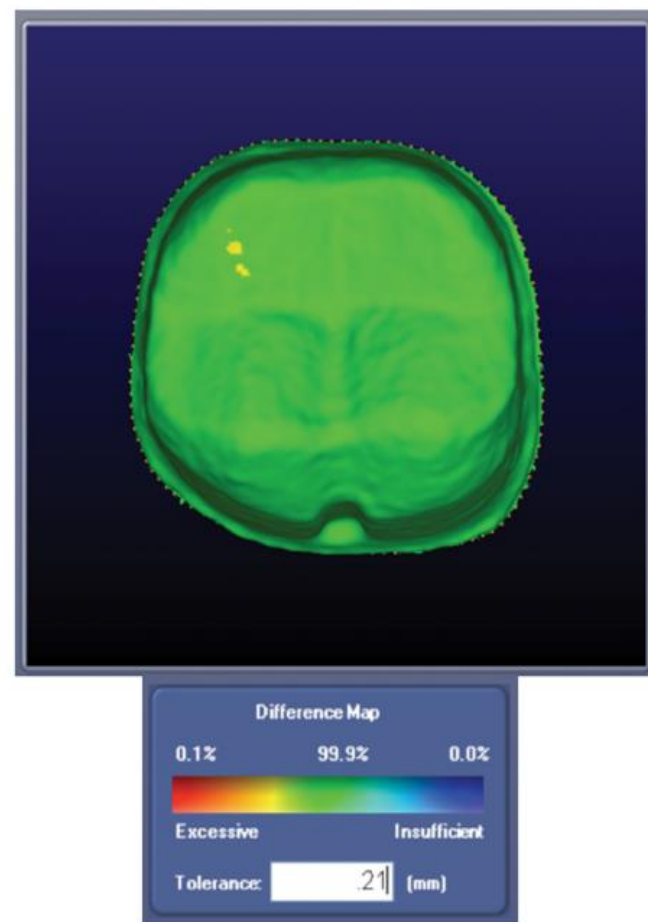
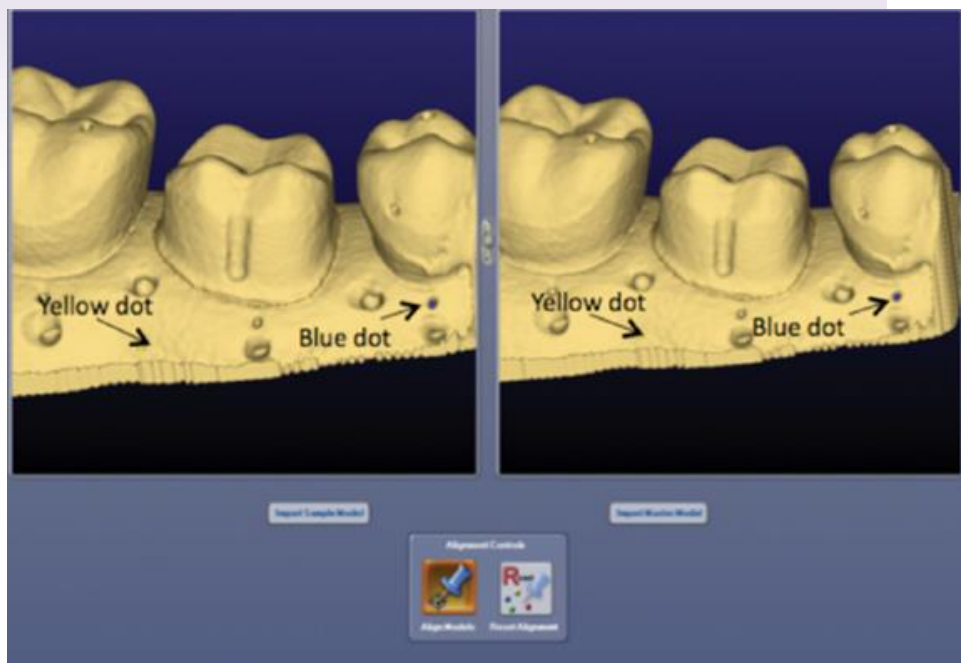


Figure 9. The Difference Map

Note: The accuracy of the alignment of the two models is 99.9 percent with a tolerance of 0.21 mm.

# Inter- and Intrarater Reliability Using Different Software Versions of E4D Compare in Dental Education

Richard S. Callan, DMD, EdS; Jeril R. Cooper, DMD; Nancy B. Young, DMD; Anthony G. Mollica, DMD; Alan R. Furness, DMD; Stephen W. Looney, PhD

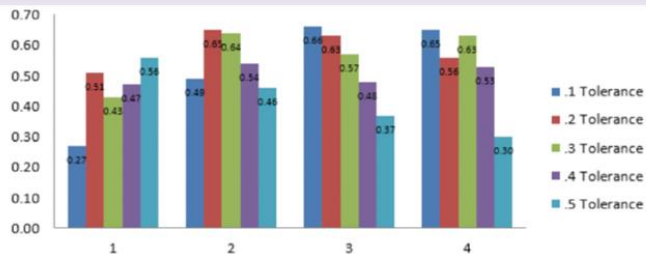


Figure 2. Interrater reliability using E4D design center (version 4.6.0.40) and E4D Compare (version 1.0): 1=dots prescan, 2=dots scan, 3=landmarks prescan, 4=landmarks scan

Note: A value of 0.75 was considered minimally acceptable in terms of adequate reliability.

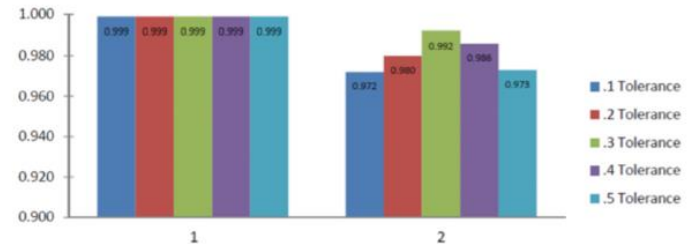


Figure 4. Interrater reliability using Nevo scanner (version 5.0.1.6) and E4D Compare (version 2.0): 1=prescan, 2=scan

Note: A value of 0.75 was considered minimally acceptable in terms of adequate reliability.

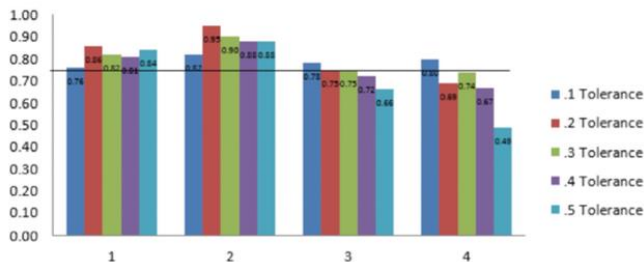


Figure 3. Intrarater reliability using E4D design center (version 4.6.0.40) and E4D Compare (version 1.0): 1=dots prescan, 2=dots scan, 3=landmarks prescan, 4=landmarks scan

Note: A value of 0.75 (shown in horizontal line) was considered minimally acceptable in terms of adequate reliability.

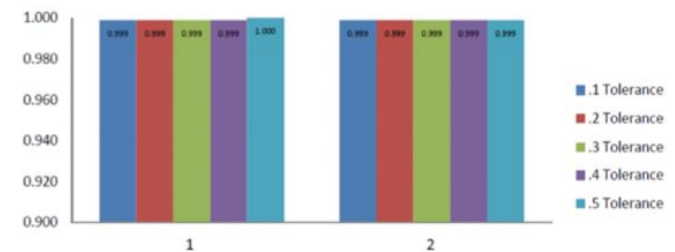


Figure 5. Intrarater reliability using Nevo scanner (version 5.0.1.6) and E4D Compare (version 2.0): 1=prescan, 2=scan

Note: A value of 0.75 was considered minimally acceptable in terms of adequate reliability.

# Effect of Employing Different Typodonts When Using E4D Compare for Dental Student Assessment

Richard S. Callan, DMD, EdS; Jeril R. Cooper, DMD; Nancy B. Young, DMD; Anthony G. Mollica, DMD; Alan R. Furness, DMD; Stephen W. Looney, PhD

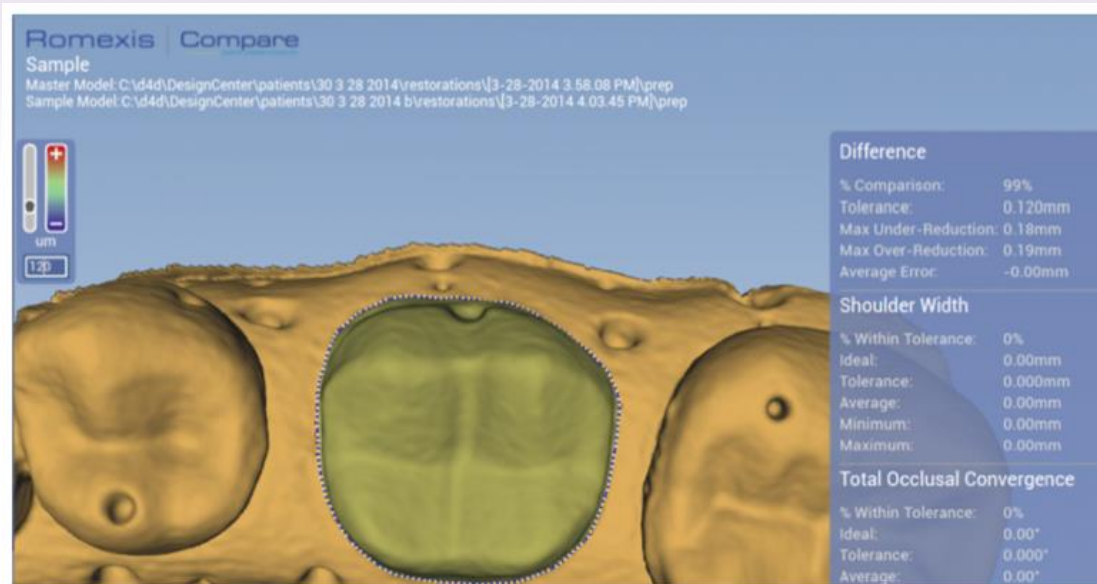


Figure 1. Ideal preparation compared to second scan of ideal preparation at 0.12 mm tolerance level

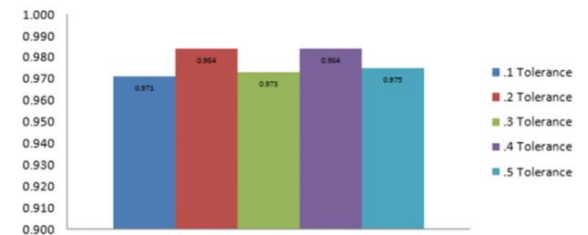


Figure 2. Intratester reliability using Nevo scanner (software version 5.0.1.6), E4D Compare (software version 2.0), and ten different typodonts

Note: A value of 0.75 was considered minimally acceptable in terms of adequate reliability.

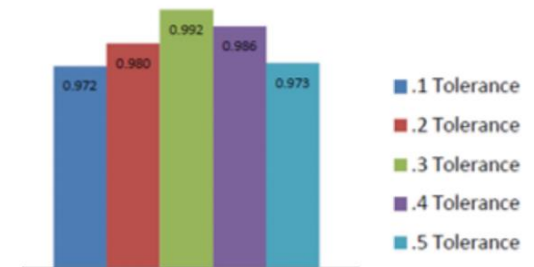


Figure 3. Intertester reliability with Nevo scanner (software version 5.0.1.6), E4D Compare (software version 2.0), and five faculty members using the same typodont

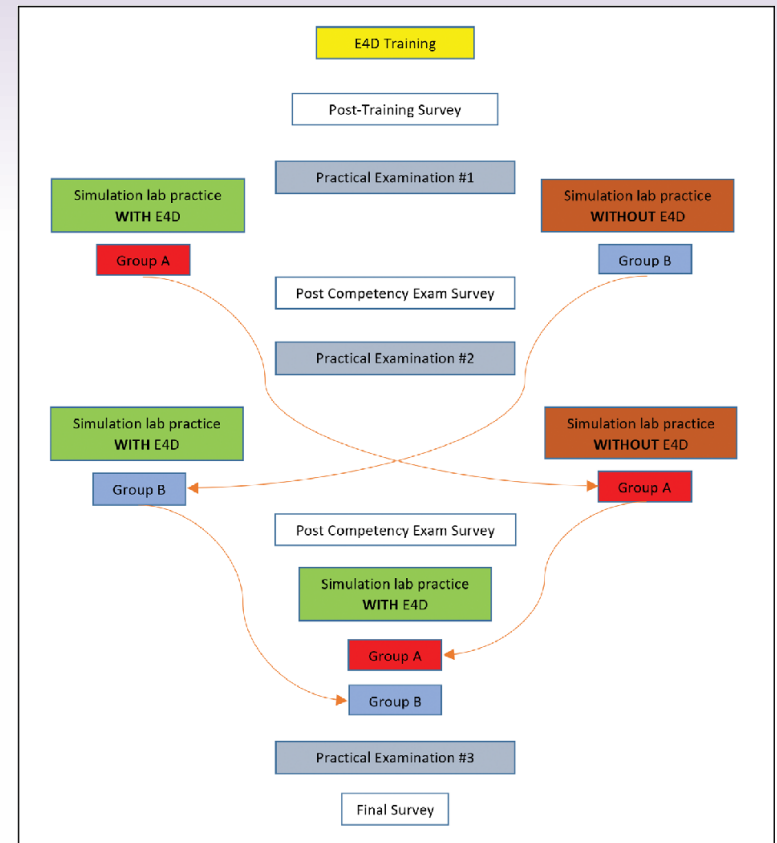
Note: A value of 0.75 was considered minimally acceptable in terms of adequate reliability.



# Effectiveness and Feasibility of Utilizing E4D Technology as a Teaching Tool in a Preclinical Dental Education Environment

Richard S. Callan, D.M.D., Ed.S.; Christie L. Palladino, M.D., M.Sc.;  
Alan R. Furness, D.M.D.; Emily L. Bundy, D.M.D.; Brittany L. Ange, M.S.

Even so, when given the opportunity to utilize the technology in preparation for the competency exam, surprisingly few students participated. The actual utilization rates (Table 5) were much less than one might anticipate and much lower than the percentage of students indicating interest on the surveys. We should emphasize that participation in this study was voluntary as was the amount of time each student spent using the technology when it was made available. Anecdotally, faculty members working in the simulation lab noted that students were more apt to request feedback from the specific professor who would be grading the competency exam than to visualize the difference themselves utilizing the E4D technology. This may suggest students were





# Integrating CAD/CAM into the Fixed Prosthodontics Module

- 14 weeks, 15 sessions: 4 Single Units & 2 FPDs
- #20 PFM Preparation & Provisional Project
- Complete Project Self-Evaluation
- Scan & Compare #20 Prep. Project in Rotations
- Rubric Evaluation Bench-top Quiz
- #20 PFM Preparation & Provisional Exam

# Module Timeline

	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8
<b>Traditional Fixed Session</b>	#30 Gold Crown Prep	#30 Provisional	#30 PFM Prep	#20 PFM Prep & Provisional	#20 PFM Prep & Provisional	#20 PFM Finish Prep & Provisional	#14 PFM Prep & Provisional	
<b>Planmeca Integration</b>							Planmeca Rotation (Scan & Compare) 2 hours	Planmeca Rotation (Scan Only) Groups of 3 for 1 ½-2 hrs

	Session 9	Session 10	Session 11	Session 12	Session 13	Session 14	Session 15	Session 16
<b>Traditional Fixed Session</b>	#14 PFM Cont.	Anterior PFM Prep	#20 Prep Evaluation Quiz	#12-14 FPD	#12-14 FPD	#8-10 FPD	#8-10 FPD	SFP Exam
<b>Planmeca Integration</b>	Planmeca Rotation (Scan & Compare) 2 hours	Planmeca Rotation (Scan & Compare) 1 hour	Planmeca Rotation (Scan only) Groups of 3 for 1 ½-2 hrs		Planmeca Rotation (Scan & Compare) 2 hours		Planmeca Rotation (Scan & Compare) 3 hours	

# Rotation Overview

68 Students, 7 Laptops, 10 Rotations embedded in 5 Sessions

Oct 13th		Oct 19th		Oct 20th	Oct 27th		Nov 2nd	
9:30-10:30	10:30-11:30	9:00-10:00	10:00-11:00	10:30-11:30	9:00-10:00	10:00-11:00	9:00-10:00	10:00-11:00
E4D Laptop 1								E4D Laptop 2
	E4D Laptop 1			E4D Laptop 2				
		E4D Laptop 1						
			E4D Laptop 1				E4D Laptop 2	
			E4D Laptop 2				E4D Laptop 1	
	E4D Laptop 2	E4D Laptop 2		E4D Laptop 1				E4D Laptop 1
E4D Laptop 2					E4D Laptop 1			
						E4D Laptop 1		
E4D Laptop 4					E4D Laptop 2			
						E4D Laptop 3		
					E4D Laptop 3	E4D Laptop 2		
E4D Laptop 3								
	E4D Laptop 3							E4D Laptop 3
		E4D Laptop 3		E4D Laptop 3				
			E4D Laptop 3				E4D Laptop 3	
	E4D Laptop 4	E4D Laptop 4						
		E4D Laptop 4		E4D Laptop 4			E4D Laptop 4	
	E4D Laptop 6							E4D Laptop 4
E4D Laptop 6					E4D Laptop 4			
						E4D Laptop 5		
						E4D Laptop 4		
E4D Laptop 5					E4D Laptop 5			



# Planmeca Scan Only Groups



# Individual Compare Rotations





# Planmeca Compare Rotations





Sample

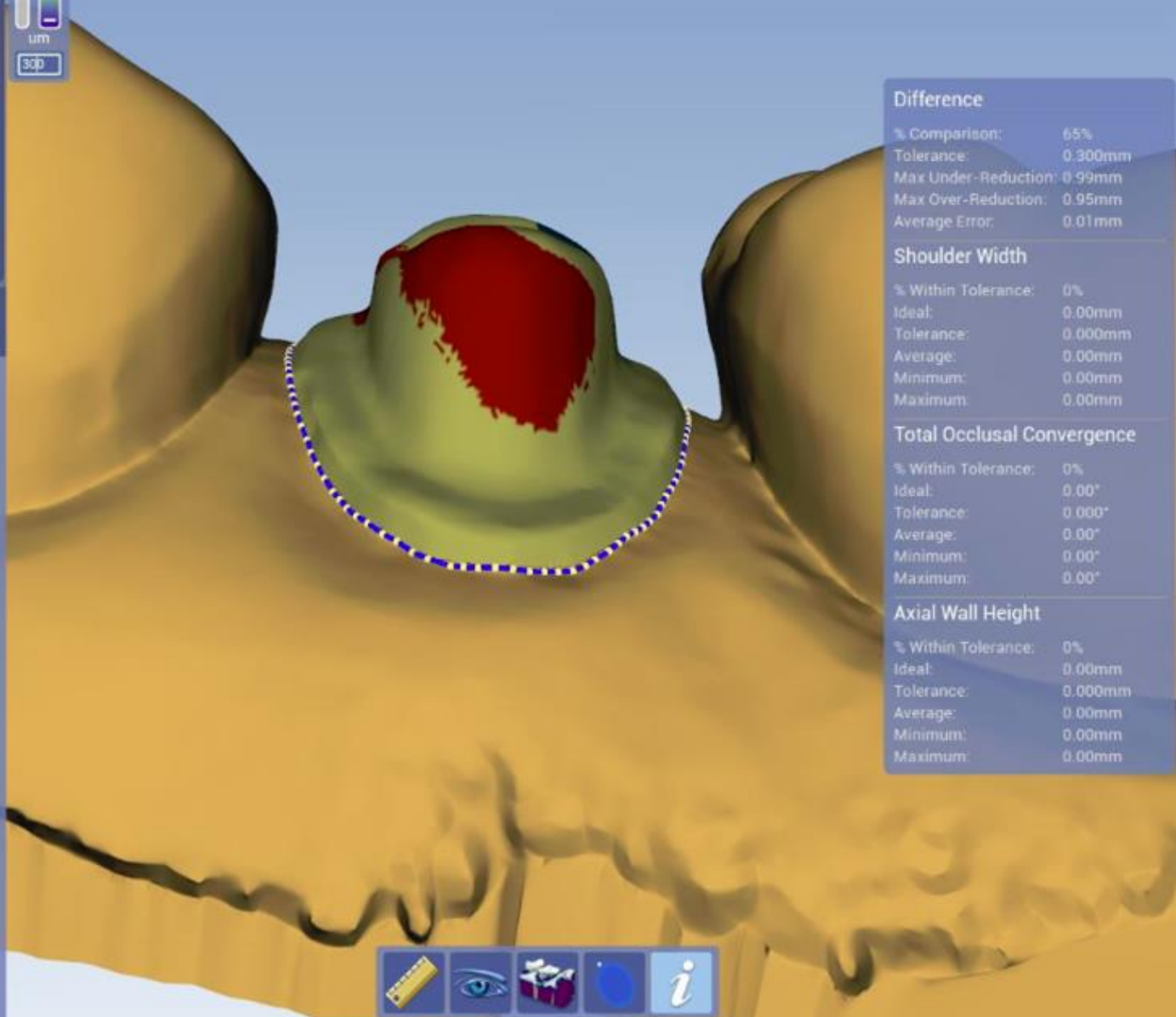
Master Model: C:\Users\E4D User\Desktop\Compare Master (Fixed Pros)\Master Prep

Sample Model: C:\Users\E4D User\AppData\Local\Temp\CadCamTemp\patients\79\5FP 59\restorations\11-12-2015 9:27:37 AM\prep



um

3dp



Difference	
% Comparison:	65%
Tolerance:	0.300mm
Max Under-Reduction:	0.99mm
Max Over-Reduction:	0.95mm
Average Error:	0.01mm
Shoulder Width	
% Within Tolerance:	0%
Ideal:	0.00mm
Tolerance:	0.000mm
Average:	0.00mm
Minimum:	0.00mm
Maximum:	0.00mm
Total Occlusal Convergence	
% Within Tolerance:	0%
Ideal:	0.00°
Tolerance:	0.000°
Average:	0.00°
Minimum:	0.00°
Maximum:	0.00°
Axial Wall Height	
% Within Tolerance:	0%
Ideal:	0.00mm
Tolerance:	0.000mm
Average:	0.00mm
Minimum:	0.00mm
Maximum:	0.00mm



# Faculty Training

## **1) Clinical Faculty Training (8 hrs - 4/15)**

Simulation by Ms. Elizabeth Pastrana (Planmeca)

## **2) Preclinical Lead Faculty Training (4 hrs – 6/15)**

Simulation by Dr. Justin Chi, Planmeca trainer turned dentist!

## **3) Faculty Live Patient Training (4 hrs. – 7/15)**

Three patient cases with Ms. Pastrana

## **4) Adjunct/Part-Time Faculty (4 hrs – 10/15)**

Simulated Experiences with Drs. Brian Chui, Sandra Farah-Franco, and Brent Fung

# Student Training

- D1 Year
  - Compare Wax-ups & Reflection Portfolios
- D2 Year
  - CAD/CAM Module
  - Fixed Prosthodontics Integrated Course
- D3 Year
  - 2 Self-Guided Rotations with Reflection
  - Identified Clinical “Super-Users” to assist colleagues and relieve clinical faculty burden



# Planmeca FIT Design Rotation Checklist

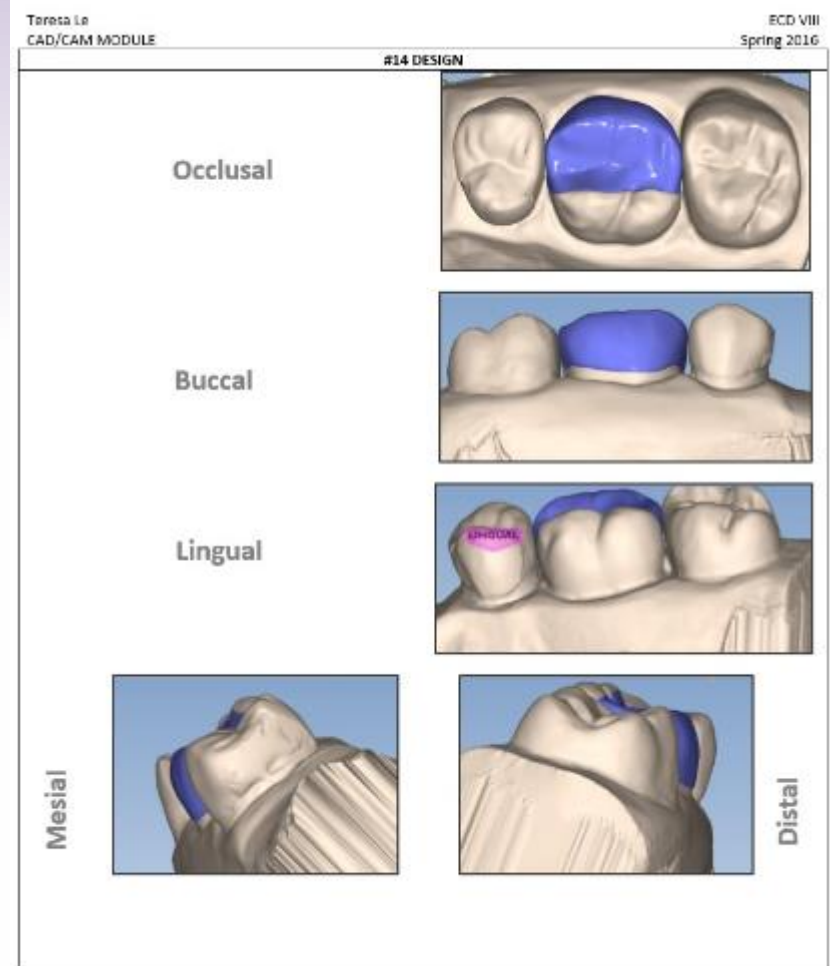
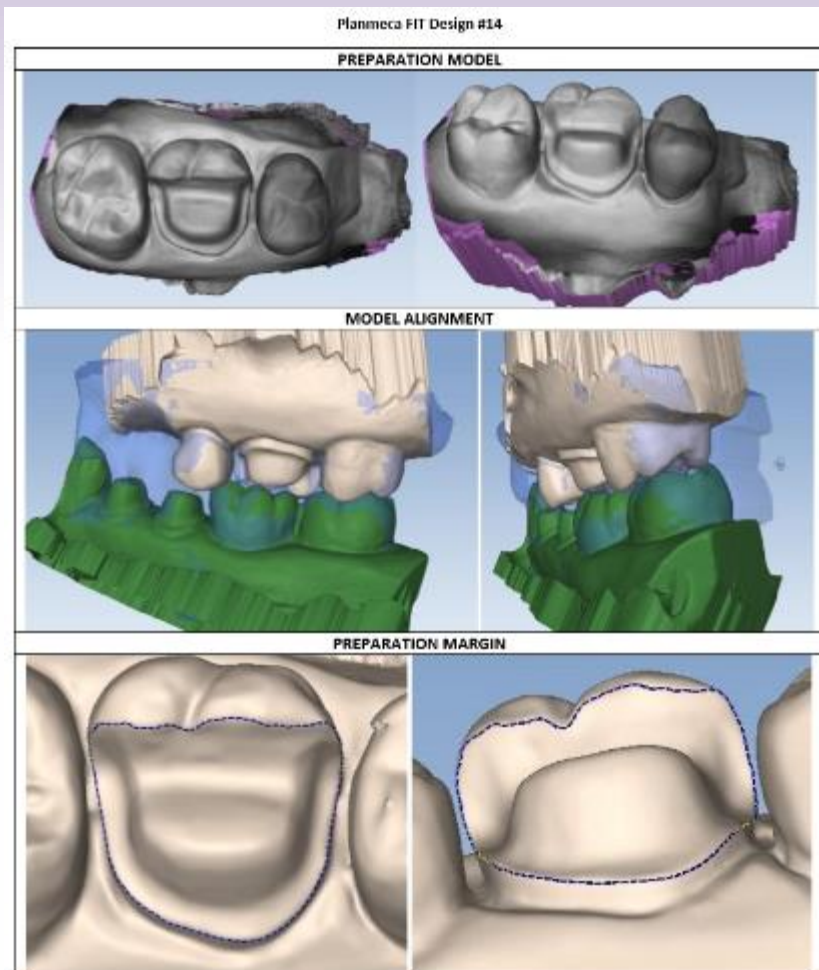
Please take note of the time you start and when you are ready to send to mill.

1. Preparation Model\* - Complete data capture including adjacent teeth & contact areas.
2. Model Alignment\* - Show proper intercuspation from lingual and distal views.
3. Preparation Margins\* – Show margins clearly defined
4. Show Selection Tool area – Did this feature help you to marginate easier/better?
5. Design Pictures\* - B/O/L/M/D pictures to show all of the following items:
  - Anatomy & Contour in harmony with adjacent teeth
  - Coincident Marginal Ridge and Cusp Ridge heights
  - Proper Occlusal and Proximal Contact Areas
  - Proper Embrasure Form
  - Proper Material Thickness
  - Proper Surface Texture/Smoothness
6. Thoughtful Sprue Placement\*
7. Time used before ready to send to milling unit in minutes.
8. Reflection:
  - a. How to generally improve the design or future designs.
  - b. Which controls/functions do you need to learn how to use more effectively?
  - c. Has this improved your understanding and speed of use of Planmeca FIT?
  - d. Based on time from imaging to design to mill, what specific things can be done to improve efficiency in imaging technique, design technique, milling technique?
  - e. Is there anything that can be done prior to imaging, in the preparation phase to improve the entire process?
9. What Troubleshooting Problems and Solutions do you have to add to a Planmeca FIT FAQ Guide?

\* - Required pictures (you can take a few more if you have questions about how to approach something).

Assignment Due uploaded to Sharepoint one week after your rotation date.

# Student Planmeca Design Assignment

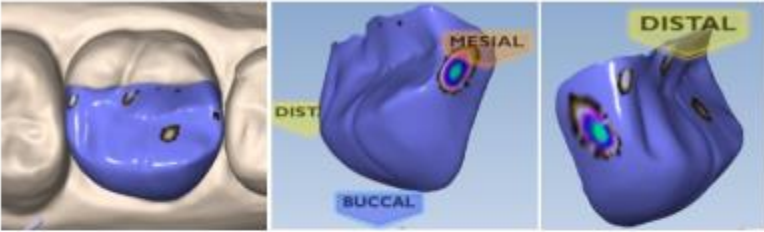


# Student Planmeca Design Assignment

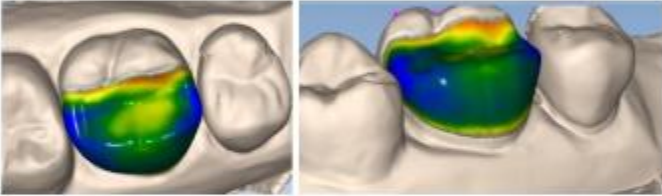
Teresa La  
CAD/CAM MODULE

ECD VIII  
Spring 2016

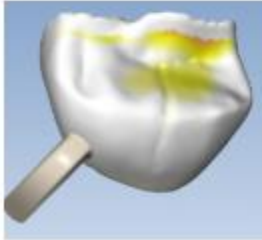
**#14 CONTACT AREAS**



**# MATERIAL THICKNESS**



**SPRUE PLACEMENT**



Time spent: 1.5 hours

Teresa La  
CAD/CAM MODULE

ECD VIII  
Spring 2016

## Reflection

### a. How to improve the design or future design generalizing?

With more practice, I hope the design functions will become more easy to use and control.

I also think additional training and demonstration would be beneficial. There ought to be a more systematic approach to CAD/CAM designing, especially at the fine-tuning stage, and I would like to see how it's properly done.

### b. Which controls/functions do you need to learn how to use better?

Mostly Freeform Change tools. I have a difficult time controlling how/how much each function affects my restoration design.

### c. Has this improved your understanding and speed of use of Planmeca HIT?

I definitely still need to work on speed. However, this exercise did help me to learn to work with the program better.

### d. Based on time from image to design to mill, what specific things can be done to improve efficiency in imaging technique, design technique, mill technique?

Be more adept at scanning; follow the recommended sequence of designing to stay efficient; learn how to use each function better in order to use them appropriately where needed; be able to recognize how modification in one area can potentially affect others, and avoid making drastic changes.

### e. Is there anything that can be done prior to imaging, in the preparation phase to improve the entire process?

The prep should be evaluated in person for adequacy of reduction, and clearance with adjacent and opposing tooth/teeth. If there's inadequateness/deficiency in any of those areas, the designing process is not going to produce a sound restoration that fits.

### Selection Tool Area – did this feature help you to marginate easier/better?

Yes

### What trouble shooting problems and solutions do you have to add to a Planmeca HIT FAQ Guide?

I learned from Dr. Chui that, when the 'View Bite Registration' icon is selected, none of the Freeform Change Tools will work (even though it shows that the tool is selected).

# CAD/CAM Design Rotation Results

<b>Design Attempt</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
<b>Time (in mins)</b>	<b>80</b>	<b>53</b>	<b>47</b>	<b>37</b>
<b>Students Reporting</b>	<b>60</b>	<b>53</b>	<b>33</b>	<b>24</b>

# Integration Keys

- Baby Steps!
  - Learn Romexis, Scan, Design, etc. in stages.
- Get Faculty up to speed first
- Integrate throughout the Curriculum
- Practice makes Perfect! Repetition is the key.



# Rubric: 4 Categories, 5 Point Scale

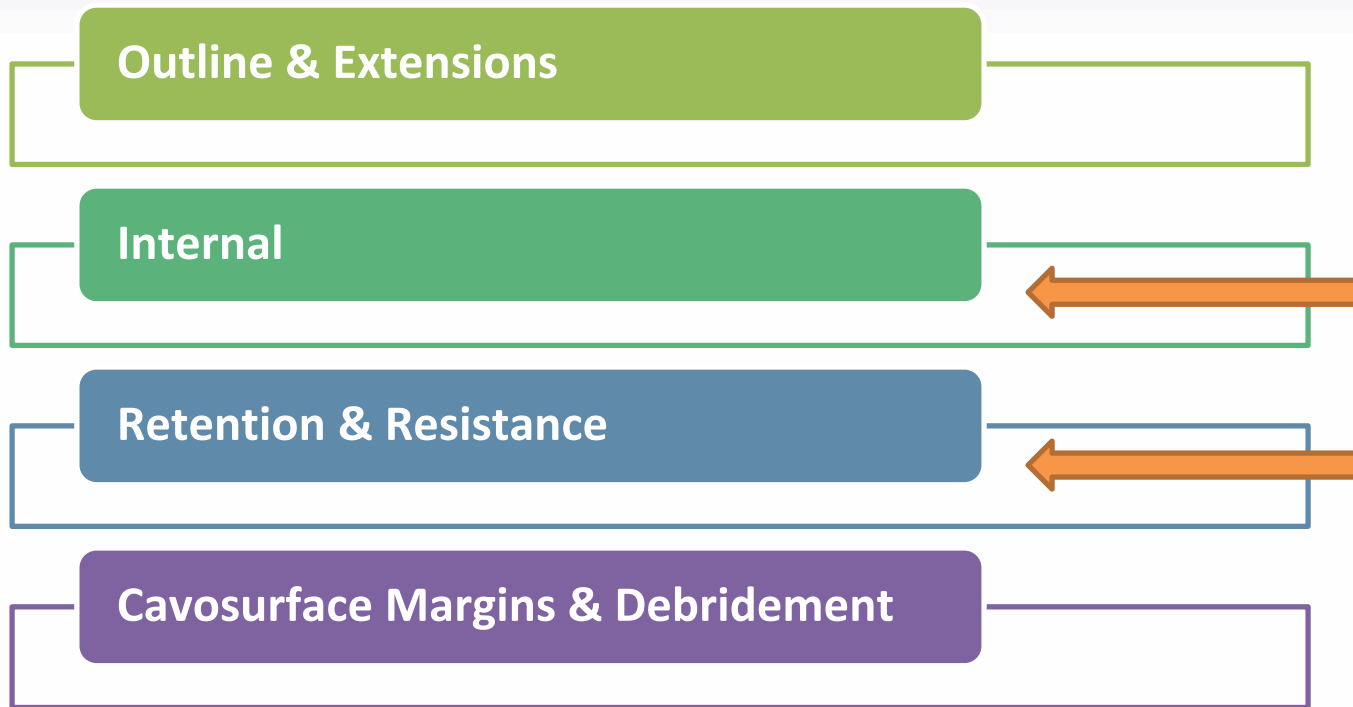
RUBRIC for Critical Skills Assessment

Categories & Scale	Optimal = 5 pts.	Slight Deviation(s) from Optimal = 4 pts.	Moderate Deviation(s), Clinically Acceptable = 3.5 pts.	Major Deviation(s), Clinically Unacceptable = 2 pts.	Multiple Major, Critical Deviation(s), Unacceptable = 0 pt.	Points (SELF)	Points (Faculty)
<b>Outline &amp; Extensions</b>	Outline includes caries, decalcification, existing restorations, esthetics, appropriate gingival extension. *Margins located 0.5mm supragingival. 0.5 mm clearance from adjacent tooth.*	Deviates slightly in isolated area(s). *Located +/- 0.25mm from optimal*	Deviates Moderately from optimal in multiple areas. *Located +/- 0.5mm from optimal*	Outline does not includes caries, decalcification, existing restorations, esthetics, appropriate gingival extension. Notable damage to adjacent teeth. *Subgingival or slightly greater than 1.0mm supragingival in multiple areas. *	Damage to adjacent teeth needing a restoration or gross alteration of axial contour.		
<b>Internal</b>	<p><b>Porcelain Occlusal Reduction:</b> 2.0mm functional cusp; 1.5mm non functional cusp .</p> <p><b>Metal Occlusal Reduction:</b> 1.5mm functional Cusp; 1.0mm non-functional.</p> <p><b>Axial Reduction:</b> Porcelain: Uniform 1.3mm. Metal: Uniform 0.7mm.</p> <p>Proper 3-plane functional cusp; 2-plane non functional cusp.</p> <p>Maintains tooth morphology. Path of insertion and reduction is appropriate for clinical situation. Smooth preparation transitions between planes.</p>	<p><b>Occlusal Reduction:</b> functional cusp +/- 0.25mm of optimal; non-functional cusp +0.25mm of optimal</p> <p><b>Axial wall reduction:</b> Slight deviation from optimal in isolated area(s). Adequate reduction 3-plane functional cusp; 2-plane non-functional cusp.</p> <p>Maintains most tooth morphology. Path of insertion and reduction is appropriate.</p>	<p><b>Occlusal Reduction:</b> functional cusp +/- 0.50mm of optimal; non-functional cusp +0.50mm of optimal.</p> <p><b>Axial Wall Reduction:</b> Moderate Deviation from optimal in multiple areas; porcelain: 1.0-1.5mm; metal: 0.5-1.0mm.</p> <p>Adequate reduction 3-plane functional cusp; 2-plane non-functional cusp.</p> <p>Minimally maintains tooth morphology. Path of insertion and reduction is adequate.</p>	Major Deviation in reduction affecting clinical success. Occlusal Morphology lacking or insufficient. Poor transition(s).	Severe over or under-reduction which jeopardizes clinical success.		
<b>Retention &amp; Resistance</b>	Occlusal convergence is 6-10 degrees (especially outermost walls). Minimally 3.0mm first plane axial wall heights.	Occlusal convergence is 11-15 degrees (especially outermost walls). Minimally 2.75mm first plane axial wall heights.	Occlusal Convergence 16 to 20 degrees (especially outermost walls). 2.5mm wall height with supplemental retention.	Occlusal Convergence greater than 20 degrees (especially outermost walls). Less than 2.5mm wall height without supplemental retention. Axial wall(s) undercut.	Gross Axial wall undercut or Gross Overtaper.		
<b>Cavosurface Margins &amp; Debridement</b>	Appropriate finish line for Restorative Design. Internally smooth, continuous, single finish line. No debris present.	Slight deviation in isolated area(s). Continuous, single finish line.	Moderate Deviation from optimal in multiple areas or moderate amount. Slight debris present. Continuous, single finish line.	Unknown finish line form. Slight soft tissue trauma. Multiple and/or discontinuous finish lines. Enamel lip/unsupported tooth structure. Presence of moderate debris.	Severe tissue trauma. Overly rough, affecting final impression. Presence of severe debris.		

Total points (sum of above; 20 points max/14 points to pass)

\*For SimClinic only\*

# Compare : Best Category Replacements



# Evaluation Quiz #20 Preparation



# Self Evaluation Quiz Results

## With vs. Without Compare Rotation

Group Statistics					
	Compare Rotation (1 Yes/2 NO)	N	Mean	Std. Deviation	Std. Error Mean
SFP Evaluation Quiz percentage	Compare Rotation	35	84.314	9.8392	1.6631
	No Compare Rotation	32	81.469	9.8733	1.7454

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2- tailed)	Mean Differen ce
SFP Evaluation Quiz percentag e	Equal variances assumed	.101	.752	1.18 0	65	.242	2.8455
	Equal variances not assumed			1.18 0	64.4 25	.242	2.8455

**Not Significant!**



# #20 PFM Exam Evaluation Correlation

## Faculty Grades vs. Student Self Evaluation

		Faculty Exam Percentage Total	Self-Exam Total
Faculty Exam Percentage Total	Pearson Correlation	1	.427**
	Sig. (2-tailed)		.000
	N	67	67
Self-Exam Total	Pearson Correlation	.427**	1
	Sig. (2-tailed)	.000	
	N	67	67

\*\* . Correlation is significant at the 0.01 level (2-tailed).

**Significant!**

# #20 PFM Exam Evaluation Correlation

## Compare vs. Student Self Evaluation

		Correlations			
		250	300	400	Self-Exam Total
250	Pearson Correlation	1	.987**	.882**	.118
	Sig. (2-tailed)		.000	.000	.340
	N	67	67	67	67
300	Pearson Correlation	.987**	1	.933**	.152
	Sig. (2-tailed)	.000		.000	.221
	N	67	67	67	67
400	Pearson Correlation	.882**	.933**	1	.213
	Sig. (2-tailed)	.000	.000		.084
	N	67	67	67	67
Self-Exam Total	Pearson Correlation	.118	.152	.213	1
	Sig. (2-tailed)	.340	.221	.084	
	N	67	67	67	67

\*\* . Correlation is significant at the 0.01 level (2-tailed).

**Not Significant!**

# #20 PFM Exam Evaluation Correlation

## Faculty Grades vs. Compare

		Correlations			
		250	300	400	Faculty Exam Percentage Total
250	Pearson Correlation	1	.987**	.882**	.334*
	Sig. (2-tailed)		.000	.000	.006
	N	67	67	67	67
300	Pearson Correlation	.987**	1	.933**	.312*
	Sig. (2-tailed)	.000		.000	.010
	N	67	67	67	67
400	Pearson Correlation	.882**	.933**	1	.300*
	Sig. (2-tailed)	.000	.000		.014
	N	67	67	67	67
Faculty Exam Percentage Total	Pearson Correlation	.334**	.312*	.300*	1
	Sig. (2-tailed)	.006	.010	.014	
	N	67	67	67	67

\*\* . Correlation is significant at the 0.01 level (2-tailed).

\* . Correlation is significant at the 0.05 level (2-tailed).

**Most Significant!**

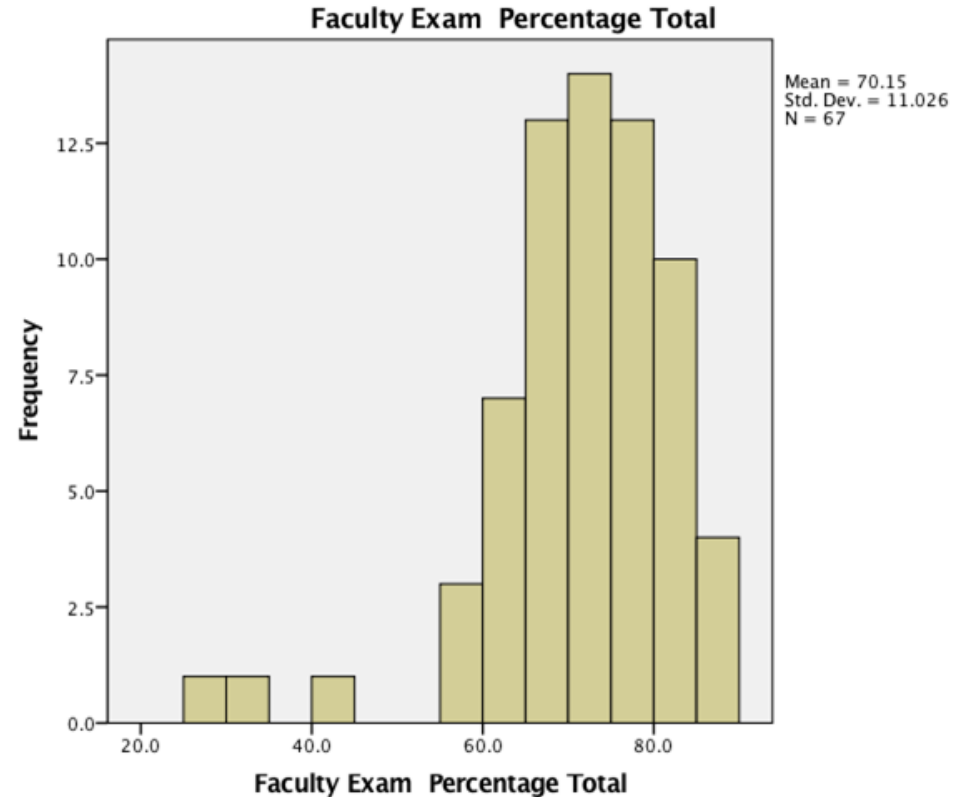
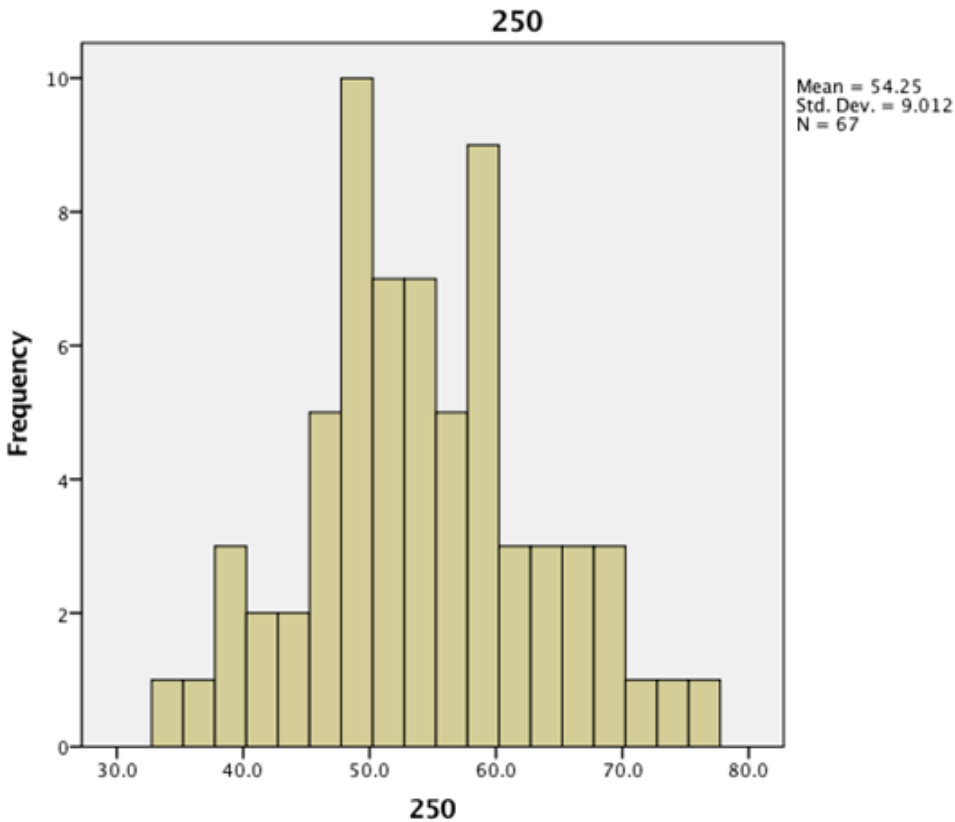
# #20 PFM Exam Evaluation

## Descriptive Statistics

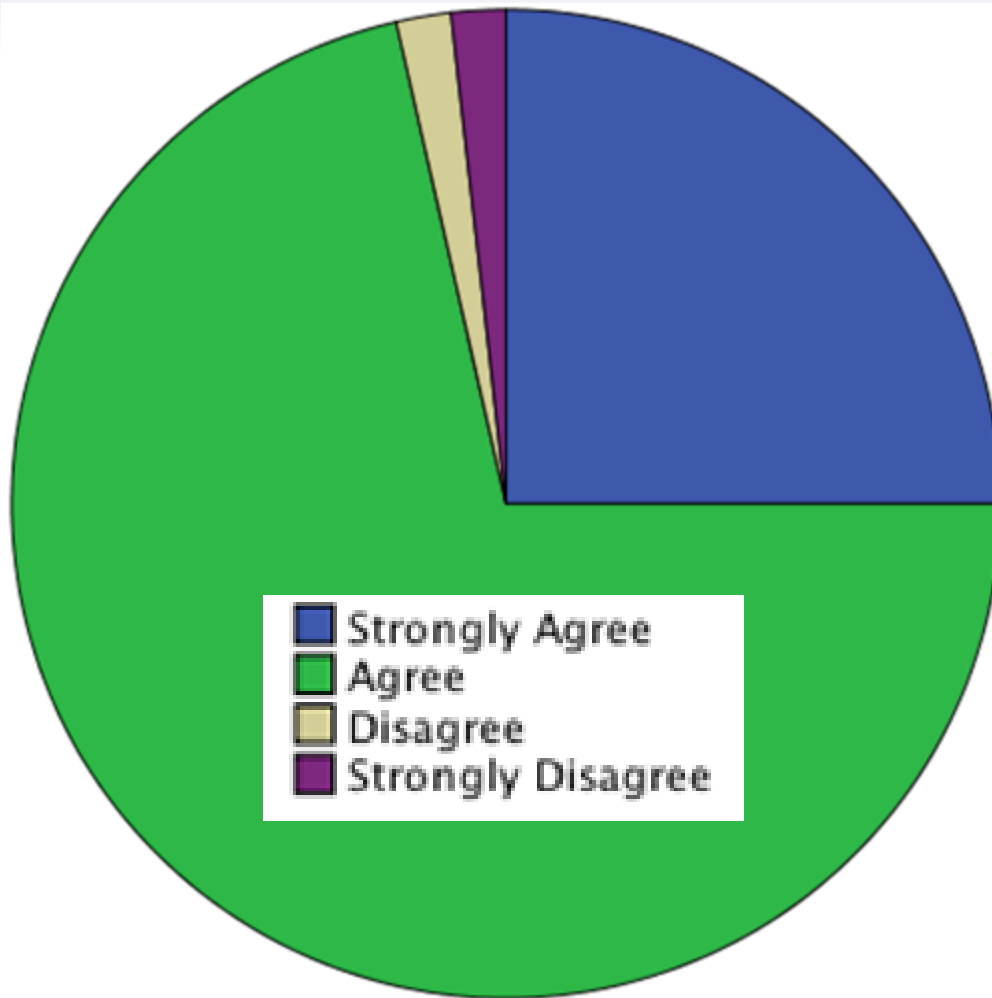
		Statistics	
		250	Faculty Exam Percentage Total
N	Valid	67	67
	Missing	0	0
Mean		54.254	70.149
Median		53.000	72.500
Std. Deviation		9.0124	11.0258
Variance		81.223	121.568
Skewness		.172	-1.825
Std. Error of Skewness		.293	.293
Kurtosis		-.210	4.967
Std. Error of Kurtosis		.578	.578
Range		42.5	57.5
Minimum		34.0	27.5
Maximum		76.5	85.0



# #20 PFM Exam Evaluation Histograms



# Student Surveys: Demonstrated areas in need of improvement in my prep



Other Survey Items	Agree/ Strongly Agree
Enabled me to make meaningful improvements	86%
Allowed me to perform better on the exam	75%
CDM should continue to provide Planmeca Compare	89%
I would like to utilize Planmeca Compare for other preparations (Class I, II, III....)	71%

# What Compare Does Well!

- Visual aide
- Adjunct teacher
- Excellent formative feedback
- Undercut/occlusal convergence
- Measurements: Axial reduction, Axial wall height
- Promotes self-improvement in most students

# Current Limitations

- Only gives measurable differences for surface mapped discrepancies
- Too operator dependent for compared surface area
- Limited functionality for Outline and Cavosurface categories currently
- Internal and Retention/Resistance can be graded (still dependent on the selection area)



# The Validity of Using E4D Compare's “% Comparison” to Assess Crown Preparations in Preclinical Dental Education

Richard S. Callan, DMD, EdS; Van B. Haywood, DMD; Jeril R. Cooper, DMD;  
Alan R. Furness, DMD; Stephen W. Looney, PhD

**Table 2. Agreement between faculty-generated grades and scores based on E4D Compare on three practical exams at five levels of tolerance**

Practical Exam	E4D Tolerance (mm)	Spearman's Correlation	Disposition	95% C.I.	p-value
1	0.1	0.47	Weak	(0.28, 0.63)	<0.001
	0.2	0.54	Moderate	(0.36, 0.68)	<0.001
	0.3	0.55	Moderate	(0.37, 0.69)	<0.001
	0.4	0.56	Moderate	(0.39, 0.70)	<0.001
	0.5	0.55	Moderate	(0.37, 0.69)	<0.001
2	0.1	0.27	Weak	(0.05, 0.46)	0.016
	0.2	0.25	Weak	(0.03, 0.45)	0.024
	0.3	0.27	Weak	(0.05, 0.46)	0.017
	0.4	0.29	Weak	(0.07, 0.48)	0.010
	0.5	0.30	Weak	(0.08, 0.49)	0.007
3	0.1	0.36	Weak	(0.14, 0.54)	0.002
	0.2	0.36	Weak	(0.15, 0.54)	0.001
	0.3	0.38	Weak	(0.16, 0.56)	0.001
	0.4	0.35	Weak	(0.14, 0.54)	0.002
	0.5	0.32	Weak	(0.10, 0.51)	0.004

Note: Spearman's correlation values between 0.00 and 0.20 are considered negligible, values between 0.20 and 0.50 are weak, values between 0.50 and 0.80 are moderate, and values between 0.80 and 1.00 are strong.

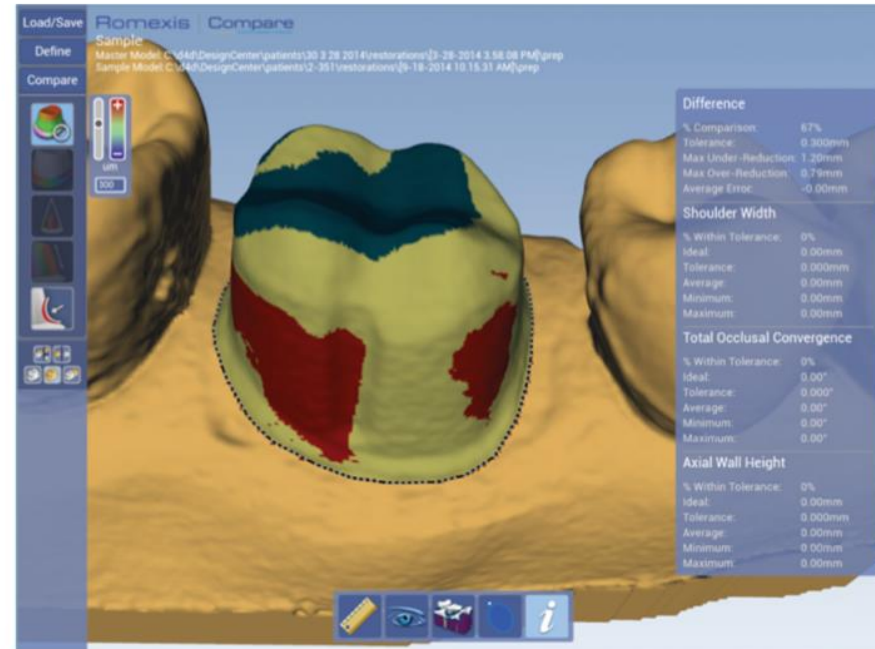


Figure 1. Student's tooth compared to ideal tooth: tolerance level 0.3 mm

Table 1. A random sampling from practical exam #2 of “% Comparison” values at various tolerance levels

Tolerance					Combined Faculty Grade
0.1 mm	0.2 mm	0.3 mm	0.4 mm	0.5 mm	
32	57	76	86	93	86.5
26	48	67	80	88	83.5
44	70	81	88	93	82.25
45	72	86	93	96	78
23*	43*	62*	75*	85*	81.5*
44	71	85	92	95	78.5
23	47	67	80	84	88.25
34	54	64	69	73	70
48**	72**	86**	92**	96**	72**
30	57	73	86	94	89

\*Low comparison scores with average faculty grade

\*\*High comparison scores with low faculty grade

## Limitations of Surface Mapping Technology in Accurately Identifying Critical Errors in Student Crown Preparations

Alan R. Furness, Richard S. Callan, J. Rodway Mackert, Anthony G. Mollica

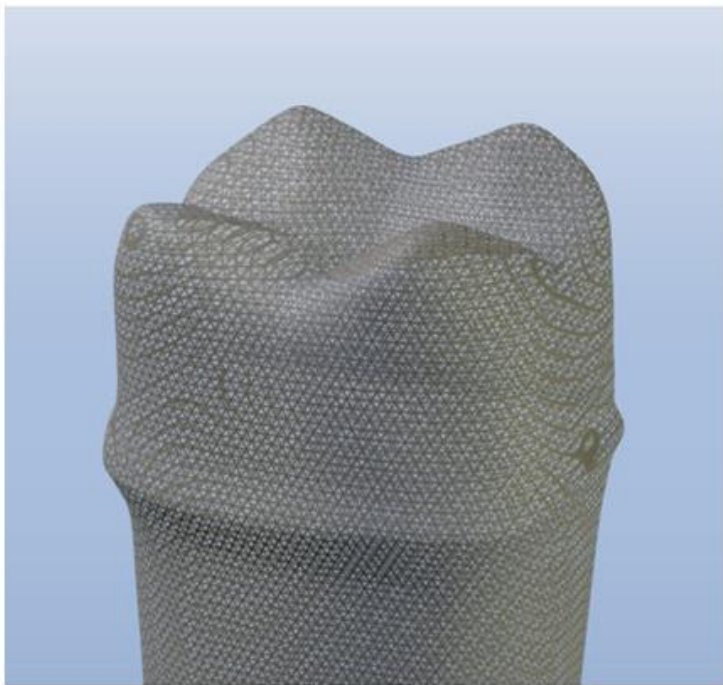


Figure 2. Illustration of 3D Mesh of Preparation, Tooth #30

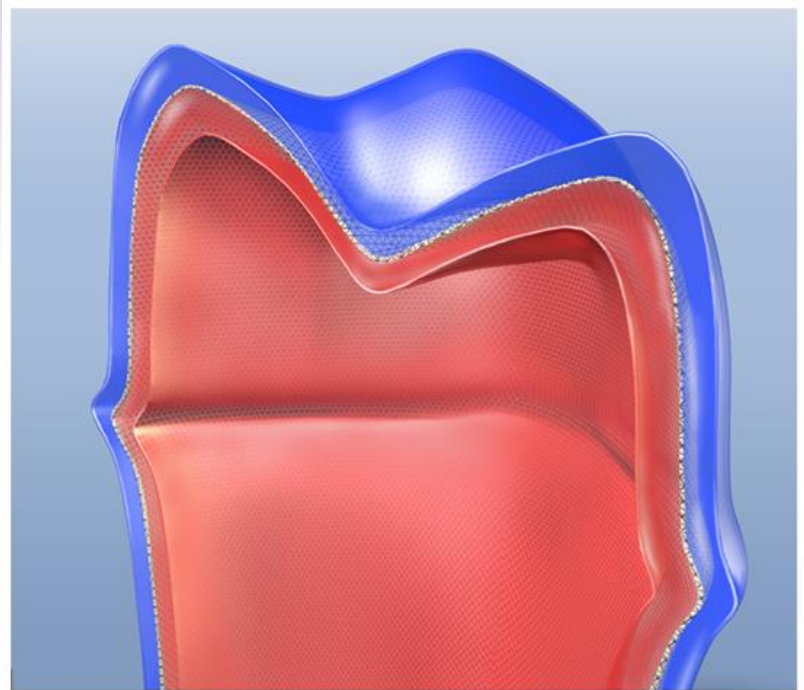


Figure 3. Tolerance zones: blue – under reduced; red- over reduced

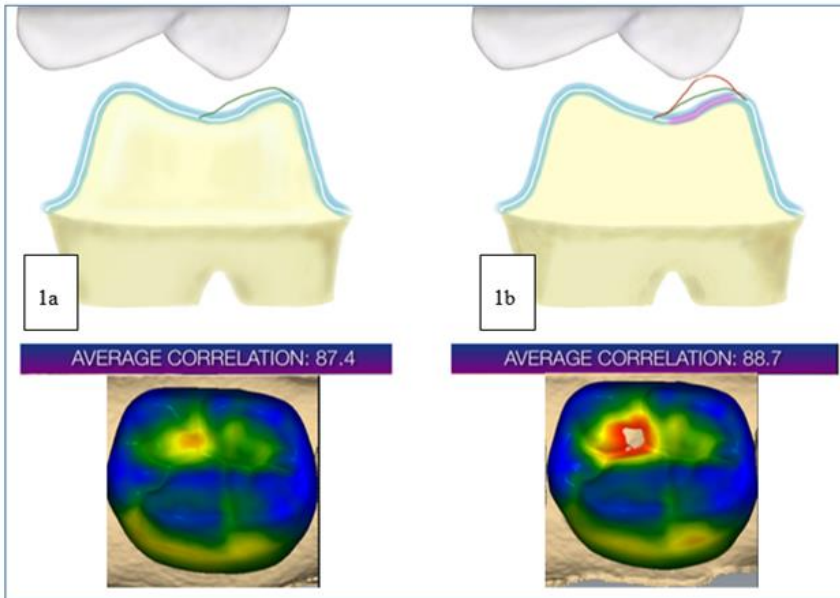


Figure 1a: Minor Under reduction -Tolerance level 0.212mm, mean correlation 87%  
 Figure 1b: Major Under reduction- Tolerance level 0.212mm, mean correlation 89%

Tolerance level	.076mm	0.1mm	.02mm	0.3mm	0.4mm	0.5mm
Ideal	100/N	100/N	100/N	100/N	100/N	100/N
Occlusal - Minor Under reduction	73/Y	81/Y	89/Y	91/N	93/N	94/N
Occlusal - Major Under reduction	84/Y	87/Y	91/Y	93/N	94/N	95/N
Minor Undercut	92/Y	97/Y	99/N	99/N	100/N	100/N
Major Undercut	94/Y	97/Y	99/N	100/N	100/N	100/N
Lip on Margin	84/Y	93/Y	98/N	100/N	100/N	100/N

**Table 1. Percent Correlation/Incorrect Determinations (% / Yes or No)**  
 E4D Compare “% Correlation” and presence of incorrect determinations of accuracy for preparation errors when compared to ideal preparation using 6 different tolerance levels

## CONCLUSION

Within the limitations of this study, it was concluded that the E4D Compare software was unable to consistently identify the critical errors within an acceptable degree of error. Because of the high correlation values and degree of error in the evaluation software, it is not suitable for a stand-alone evaluation tool at this time, but may be better served as visual feedback for the students.



**FIXP 5001: CRITERIA FOR COMPLETE CROWN PREPARATION**

Faculty Evaluation Sheet

Dentoform Number: \_\_\_\_\_ :  
GRADE

1. \_\_\_\_\_ **OCCLUSAL REDUCTION**

- A. Uniform and retains original cusp contours; all angles rounded.
- B. Occlusal clearance 1.5 - 2 mm (Optimum 1.5 mm): Occluding cusps
- C. Occlusal clearance 1 - 1.5 (Optimum 1.5 mm): Non-contacting cusps
- D. Adequate in areas of functional pathways (1.5 mm minimum).
- E. Marginal ridges and central groove reduced (1.5 mm) below adjacent teeth.
- F. The functional cusp bevel is properly reduced to position cusp tips with opposing central groove and provide reduction for buccal and lingual grooves.

2. \_\_\_\_\_ **PROXIMAL REDUCTION**

- A. Each wall converges at least 6° but no more than 8° from ideal line of draw.
- B. Plane of reduction flat with no undercut.
- C. Gingival margin clears contact with adjacent tooth by at least 1 mm.
- D. Axial walls at least 3-4 mm long, measured at the marginal ridges.
- E. No damage to adjacent teeth.

3. \_\_\_\_\_ **FACIAL-LINGUAL REDUCTION**

- A. Axial wall of functional cusp demonstrates functional-cusp bevel (parallel to or steeper than the inner incline of opposing non-functional cusp). Axial wall of non-function cusp reduced in one flat plane.
- B. Gingival 1/3 of facial and lingual surfaces converge at least 12° but no more than 16° from ideal line of draw.
- C. Axial line angles rounded but not over-reduced (maintain 6-8° convergence per wall).
- D. Axial walls at least 4 mm long, measured on facial and lingual walls.
- E. Seating/resistance groove of correct dimensions and shape, properly placed at mid-tooth, 1 mm from margins.

4. \_\_\_\_\_ **MARGINS & DRAW**

- A. A definite chamfer (0.5 mm) is present at all cavosurface margins.
- B. Cavosurface margin is smooth and within .3-.5 mm from the gingival crest.
- C. All cavosurface angles are obtuse. (140° optimum).
- D. When viewed from the occlusal, all axial surfaces are visible simultaneously.
- E. When viewed from the occlusal, all cavosurface margins are visible simultaneously.
- F. Dentoform and articulator are free of dirt and debris, bar removed.

AVERAGE: \_\_\_\_\_

Specification:		Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
1. Facial-Lingual Reduction	A. Axial wall reduction	Facial: 1.0 mm at margin, 1.5mm mid-facial to incisal Lingual provides 0.5mm margin	Slightly over / under reduced	Moderately over / under reduced	Severely over / under reduced
	B. Axial wall plane of reduction	Facial follows labial surface M/D Lingual: flat preparation wall	Slight deviation of facial surface Lingual slightly barrelled	Moderate deviation of facial surface Lingual moderately barrelled	Severe deviation of facial surface Lingual severely barrelled
	C. Occlusal convergence	6-8° per wall Appropriate path of draw	Slight -over / undertaper -B / L path of draw	Moderate overtaper Tight (<6° per wall) Moderate B / L path of draw	Severe overtaper Undercut Severe B / L path of draw
	D. Axial line angles	Reduction provides 1.0mm margin at facial and 0.5mm at lingual line angles 6-8° per wall	Slightly -over / under reduced -overtapered	Moderately -over / under reduced -overtapered Tight (<8°)	Severe -over / under reduction -overtaper Undercut
	E. Lingual wall height	Lingual wall height 1.5 mm minimum	Slightly less than 1.5mm high	Moderately less than 1.5mm	Severely less than 1.5mm high
	F. Axial wall smoothness	Walls smooth	Walls slightly rough	Walls moderately rough	Walls severely rough
GRADE					88

Specification:		Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
2. Proximal Reduction	A. Axial reduction	M/D width of prep approx 5mm 1.0mm margin at facial 0.5mm margin at lingual line angle	Slightly -over / under reduced	Moderately -over / under reduced	Severely -over / under reduced
	B. Occlusal convergence	6-8° per wall Path of draw	Slight overtaper Slight M / D path of draw	Moderate overtaper Tight (<6° per wall) Moderate M / D path of draw	Severe overtaper Undercut Severe M / D path of draw
	C. Plane of reduction	Flat Not undercut		Wall barrelled slightly	Wall barrelled moderately /severely Undercut
	D. Axial wall height	M/D wall height 4mm minimum	Slightly less than 4.0mm high	Moderately less than 4.0mm	Severely less than 4.0mm high
	E. Gingival margin clearance with opposing tooth	1mm minimum			No clearance
	F. Adjacent tooth damage	See Treatment Management			
GRADE					99

Specification:		Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
3. Incisal / Lingual Slope Reduction	A. Reduction	Incisal 2-2.5mm Lingual slope 1mm	Slightly over / under reduced	Moderately over / under reduced	Severely over / under reduced
	B. Uniformity and line angles	All angles rounded Flat lingual slope	Slightly -sharp angles -rough -concave lingual slope M/D	Moderately -sharp angles -rough -concave lingual slope M/D	Severely -sharp angles -rough -concave lingual slope M/D
	C. Incisal edge thickness and angle of reduction	Thickness 0.5-0.75 mm Lingual angle of reduction	Slightly -0.5 or >0.75 mm thick -flat or steep angle of reduction	Moderately -<0.5 or >0.75 mm thick -flat or steep angle of reduction	Severely -<0.5 or >0.75 mm thick -flat or steep angle of reduction
GRADE					82

Specification:		Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
4. Margins and Finish	A. Margin width	Facial: 1.0mm wide rounded shoulder Lingual: 0.5mm chamfer Facial and lingual margins blend smoothly in interproximal area	Facial / Lingual: slightly thin / wide Facial and lingual walls do not blend smoothly slightly F / L	Facial / Lingual: moderately thin / wide Facial and lingual walls do not blend smoothly moderately F / L	Facial / Lingual: extremely wide Slice margin (0mm width) Facial and lingual walls do not blend smoothly severely
	B. Margin definition and extension	Smooth 0.3-0.5mm above gingival crest	Slightly -rough margin ->0.5mm or <0.3mm above gingival crest	Moderately -rough margin ->0.5mm or <0.3mm above gingival crest	Extremely -rough margin ->0.5mm above gingival crest
	C. Cavosurface angle	110° optimal	Slightly steep (>110°)	Moderately steep (>110°)	Margin tipped (<110°) Margin beveled
	D. Axial wall finish	Smooth axial surfaces	Slightly rough axial surfaces	Moderately rough axial surfaces	Severely rough axial surfaces
GRADE					70

Specification:		Standard	-1 -5 Points	-5-10 Points	-10-15 Points
5. Treatment Management	A. Condition of adjacent teeth	No damage	Slight damage that can be removed with polishing	Moderate damage that changes contact shape and position	Gross damage which would require a restoration
	B. Soft tissue condition	Margin 0.3-0.5mm above gingival crest with no damage	Slight damage to gingival crest	Moderate damage to gingival crest	Gross gingival damage
	C. Dentoforn cleanliness Bar removed	Dentoforn clean Bar removed	Dentoforn dirty Bar not removed	Grader initials	
	D. Dentoforn occlusion	Teeth tight Occlusion stable	Loose teeth Slight occlusal discrepancy	Moderate occlusal discrepancy	Severe occlusal discrepancy
	E. Critical errors	Correct tooth treated			Wrong tooth treated
	F. Operating/patient position	Correct operating and patient position	Number of observed second infractions		
Penalty Points			TOTAL		
			0		

Dentiform# 20		Major Deviation/ Critical Error	Moderate Deviation	Minor Deviation	No Deviation	TOTAL
<b>1 OVER Reduction</b>						<b>10</b>
MM -Incisal/lingual slope		0-1-2-3-4-5-6-7-8-9-10				
RC -Facial/lingual		0-1-2-3-4-5-6-7-8-9-10			10	
KJ -Mesial/distal		0-1-2-3-4-5-6-7-8-9-10			10	
<b>2 UNDER Reduction</b>						<b>5</b>
MM -Incisal/lingual slope		0-1-2-3-4-5-6-7-8-9-10				
RC -Facial/lingual		0-1-2-3-4-5-6-7-8-9-10			8	
KJ -Mesial/distal		0-1-2-3-4-5-6-7-8-9-10			10	
<b>3 OVERTaper</b>						<b>9</b>
RC -Facial/lingual		0-1-2-3-4-5-6-7-8-9-10			10	
KJ -Mesial/distal		0-1-2-3-4-5-6-7-8-9-10			9	
<b>4 Draw (tight/undercut)</b>						<b>10</b>
RC -Facial/lingual		0-1-2-3-4-5-6-7-8-9-10			10	
KJ -Mesial/distal		0-1-2-3-4-5-6-7-8-9-10			10	
<b>5 Margins</b>						<b>3</b>
VH -Width, definition, extension, finish		0-1-2-3-4-5-6-7-8-9-10			6	
VH -Cavosurface angle		0-1-2-3-4-5-6-7-8-9-10			3	
<b>6 Damage and Neatness</b>						<b>10</b>
KJ -Adjacent teeth		0-1-2-3-4-5-6-7-8-9-10			10	
VH -Soft tissue		0-1-2-3-4-5-6-7-8-9-10			10	
*** -Dentiform dirty, bar		0-1-2-3-4-5-6-7-8-9-10			10	
<b>6 E4D % Comparison</b>						

TOTAL **47**

Dentiform	Tolerance (mm)					E4D #	Average	.2/.3 avg	Faculty	new	M3*100/60	I3*.4	M3+O3
1	68	90	95	97	99	2360	89.8	92.5	82	45	75	37	82
2	43	65	80	87	92	2371	73.4	72.5	69	35	58.33333	29	64
3	55	73	83	89	94	2299	78.8	78	80	46	76.66667	31.2	77.2
4	41	66	76	84	89	2363	71.2	71	79.25	45	75	28.4	73.4
5	48	70	84	91	95	2331	77.6	77	82.25	47	78.33333	30.8	77.8
6	41	66	82	88	92	2333	73.8	74	69.75	37	61.66667	29.6	66.6
7	37	55	68	78	84	3361	64.4	61.5	78.5	46	76.66667	24.6	70.6
8	51	73	87	94	97	2322	80.4	80	83	46	76.66667	32	78
9	47	69	81	88	93	2321	75.6	75	77.5	40	66.66667	30	70
10	53	74	87	93	96	2362	80.6	80.5	84	47	78.33333	32.2	79.2
11	53	74	87	94	98	2347	81.2	80.5	81.5	43	71.66667	32.2	75.2
12	51	75	88	94	97	2364	81	81.5	82.75	44	73.33333	32.6	76.6
13	49	71	80	85	89	2315	74.8	75.5	79.75	43	71.66667	30.2	73.2
14	66	86	92	95	97	2306	87.2	89	80.5	48	80	35.6	83.6
15	49	75	88	92	95	3360	79.8	81.5	76	39	65	32.6	71.6
16	47	67	79	88	93	2327	74.8	73	75.25	35	58.33333	29.2	64.2
17	42	66	77	84	89	2314	71.6	71.5	76	39	65	28.6	67.6
18	38	59	75	85	90	2302	69.4	67	78.5	47	78.33333	26.8	73.8
19	31	49	60	70	79	2353	57.8	54.5	72.25	28	46.66667	21.8	49.8
20	50	72	82	89	93	2358	77.2	77	83	47	78.33333	30.8	77.8
							75.12346		78.59877	42.6625	71.15226		72.74074
							9.516279		4.911829	6.887746	11.47958		8.916
							19.03256		9.823657	13.77549	22.95915		17.832
							94.15601		88.42242	56.43799	94.11142		90.57274
							56.0909		68.77511	28.88701	48.19311		54.90874

Dentiform	.2/.3 avg	Faculty	new	l3*.4	M3+O3
1	92.5	82	45	37	82
19	54.5	72.25	28	21.8	49.8
20	77	83	47	30.8	77.8
	75.123457	78.59877	42.6625		72.74074
	9.5162791	4.911829	6.887746		8.916
	19.032558	9.823657	13.77549		17.832
	94.156015	88.42242	56.43799		90.57274
	56.090899	68.77511	28.88701		54.90874



Specification:	Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
A. Axial wall reduction	Facial: 1.0 mm at margin, 1.5mm mid-facial to incisal Lingual provides 0.5mm margin	Slightly over / under reduced	Moderately over / under reduced	Severely over / under reduced
B. Axial wall plane of reduction	Facial follows labial surface M/D Lingual: flat preparation wall	Slight deviation of facial surface Lingual slightly barreled	Moderate deviation of facial surface Lingual moderately barreled	Severe deviation of facial surface Lingual severely barreled
C. Occlusal convergence	6-8° per wall Appropriate path of draw	Slight -over / undertaper -B / L path of draw	Moderate overtaper Tight (<6° per wall) Moderate B / L path of draw	Severe overtaper Undertaper Severe B / L path of draw
D. Axial line angles	Reduction provides 1.0mm margin at facial and 0.5mm at lingual line angles 6-8° per wall	Slightly -over / under reduced -overtapered	Moderately -over / under reduced -overtapered Tight (<8°)	Severe -over / under reduction -overtaper Undertaper
E. Lingual wall height	Lingual wall height 1.5 mm minimum	Slightly less than 1.5mm high	Moderately less than 1.5mm	Severely less than 1.5mm high
F. Axial wall smoothness	Walls smooth	Walls slightly rough	Walls moderately rough	Walls severely rough

GRADE 82

Specification:	Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
A. Axial reduction	M/D width of prep approx 5mm 1/0mm margin at facial 0.5mm margin at lingual line angle	Slightly -over / under reduced	Moderately -over / under reduced	Severely -over / under reduced
B. Occlusal convergence	6-8° per wall Path of draw	Slight overtaper Slight M / D path of draw	Moderate overtaper Tight (<6° per wall) Moderate M / D path of draw	Severe overtaper Undertaper Severe M / D path of draw
C. Plane of reduction	Flat Not undercut		Wall barreled slightly	Wall barreled moderately / severely Undertaper
D. Axial wall height	M/D wall height 4mm minimum	Slightly less than 4.0mm high	Moderately less than 4.0mm	Severely less than 4.0mm high
E. Gingival margin clearance with opposing tooth	1mm minimum			No clearance
F. Adjacent tooth damage	See Treatment Management			90

GRADE

Specification:	Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
A. Reduction	Incisal 2-2.5mm Lingual slope 1mm	Slightly over / under reduced	Moderately over / under reduced	Severely over / under reduced
B. Uniformity and line angles	All angles rounded Flat lingual slope	Slightly -sharp angles -rough -concave lingual slope M/D	Moderately -sharp angles -rough -concave lingual slope M/D	Severely -sharp angles -rough -concave lingual slope M/D
C. Incisal edge thickness and angle of reduction	Thickness 0.5-0.75 mm Lingual angle of reduction	Slightly <0.5 or >0.75 mm thick -flat or steep angle of reduction	Moderately <0.5 or >0.75 mm thick -flat or steep angle of reduction	Severely <0.5 or >0.75 mm thick -flat or steep angle of reduction

GRADE 90

Specification:	Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
A. Margin width	Facial: 1.0mm wide rounded shoulder Lingual: 0.5mm chamfer Facial and lingual margins blend smoothly in interproximal area	Facial / Lingual: slightly thin / wide Facial and lingual walls do not blend smoothly slightly F / L	Facial / Lingual: moderately thin / wide Facial and lingual walls do not blend smoothly moderately F / L	Facial / Lingual: extremely wide Steepest margin (0mm width) Facial and lingual walls do not blend smoothly severely
B. Margin definition and extension	Smooth 0.3-0.5mm above gingival crest	Slightly -rough margin ->0.5mm or <0.3mm above gingival crest	Moderately -rough margin ->0.5mm or <0.3mm above gingival crest	Extremely -rough margin ->0.5mm above gingival crest
C. Cavo-surface angle	110° optimal	Slightly steep (>110°)	Moderately steep (>110°)	Margin rounded (<110°) Margin beveled
D. Axial wall finish	Smooth axial surfaces	Slightly rough axial surfaces	Moderately rough axial surfaces	Severely rough axial surfaces

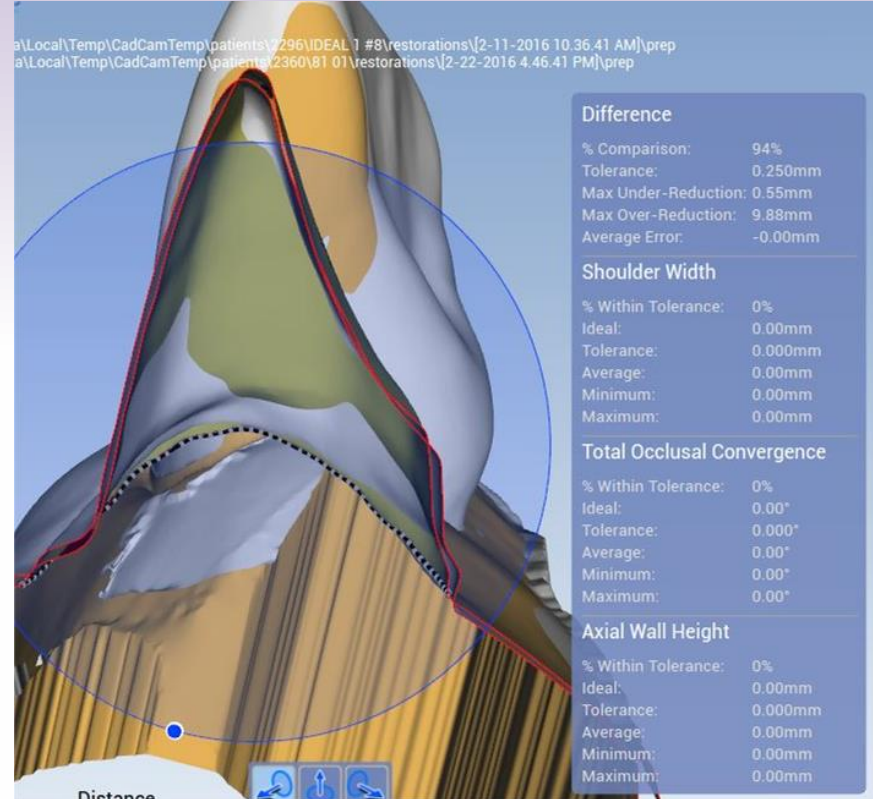
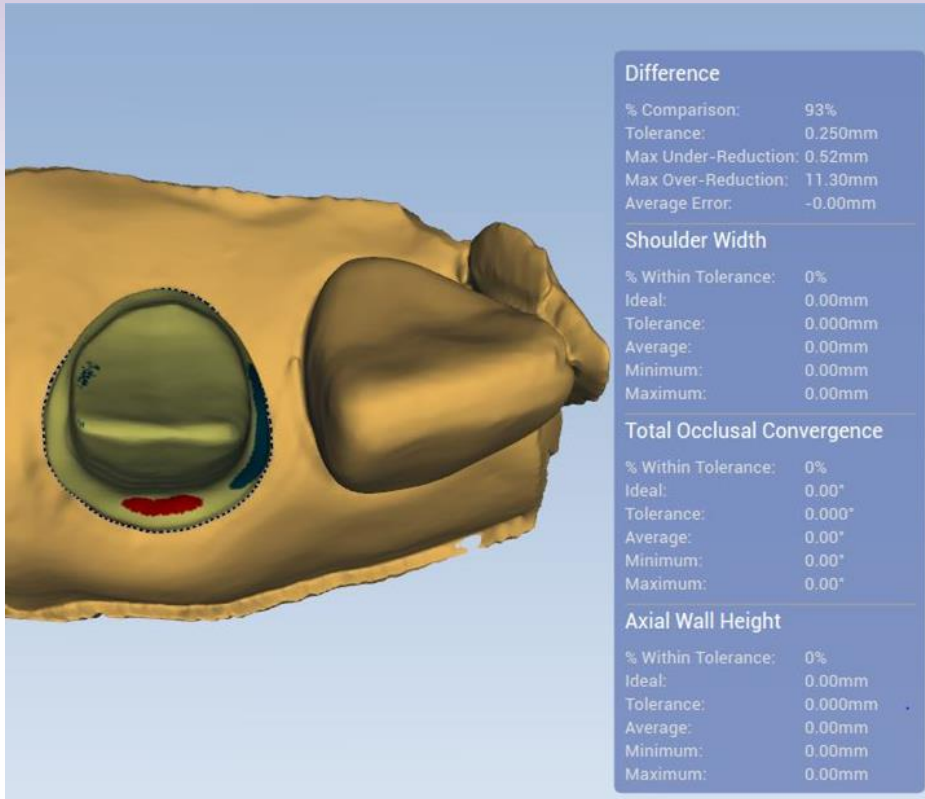
GRADE 70

Specification:	Standard	-1 -5 Points	-5-10 Points	-10-15 Points
A. Condition of adjacent teeth	No damage	Slight damage that can be removed with polishing	Moderate damage that changes contact shape and position	Gross damage which would require a restoration
B. Soft tissue condition	Margin 0.3-0.5mm above gingival crest with no damage	Slight damage to gingival crest	Moderate damage to gingival crest	Gross gingival damage
C. Dentofrom cleanliness Bar removed	Dentofrom clean Bar removed	Dentofrom dirty Bar not removed		
D. Dentofrom occlusion	Teeth tight Occlusion stable	Slight occlusal discrepancy	Moderate occlusal discrepancy	Severe occlusal discrepancy
E. Critical errors	Correct tooth treated			Wrong tooth treated
F. Operating/ patient position	Correct operating and patient position	Number of observed second infractions		

TOTAL

Dentoform# 01		Major Deviation/ Critical Error	Moderate Deviation	Minor Deviation	No Deviation	TOTAL
1 OVER Reduction						0
MM	-Incisal/lingual slope	0-1-2-3-4-5-6-7-8-9-10			9	
RC	-Facial/lingual	0-1-2-3-4-5-6-7-8-9-10		6		
KJ	-Mesial/distal	0-1-2-3-4-5-6-7-8-9-10				
2 UNDER Reduction						10
MM	-Incisal/lingual slope	0-1-2-3-4-5-6-7-8-9-10				
RC	-Facial/lingual	0-1-2-3-4-5-6-7-8-9-10				
KJ	-Mesial/distal	0-1-2-3-4-5-6-7-8-9-10			10	
3 OVERTaper						9
RC	-Facial/lingual	0-1-2-3-4-5-6-7-8-9-10				
KJ	-Mesial/distal	0-1-2-3-4-5-6-7-8-9-10		9		
4 Draw (tight/undercut)						9
RC	-Facial/lingual	0-1-2-3-4-5-6-7-8-9-10				
KJ	-Mesial/distal	0-1-2-3-4-5-6-7-8-9-10		9		
5 Margins						2
VH	-Width, definition, extension, finish	0-1-2-3-4-5-6-7-8-9-10		8		
VH	-Cavosurface angle	0-1-2-3-4-5-6-7-8-9-10	2			
6 Damage and Neatness						9
KJ	-Adjacent teeth	0-1-2-3-4-5-6-7-8-9-10		9		
VH	-Soft tissue	0-1-2-3-4-5-6-7-8-9-10			10	
***	-Dentoform dirty, bar	0-1-2-3-4-5-6-7-8-9-10				
6 E4D % Comparison						

TOTAL 45





Specification:	Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
A. Axial wall reduction	Facial: 1.0 mm at margin, 1.5mm mid-facial to incisal Lingual provides 0.5mm margin	Slightly over / under reduced	Moderately over / under reduced	Severely over / under reduced
B. Axial wall plane of reduction	Facial follows labial surface M/D Lingual: flat preparation wall	Slight deviation of facial surface Lingual slightly barreled	Moderate deviation of facial surface Lingual moderately barreled	Severe deviation of facial surface Lingual severely barreled
C. Occlusal convergence	6-8° per wall Appropriate path of draw	Slight over / undertaper B / L path of draw	Moderate overtaper Tight (<6° per wall) Moderate B / L path of draw	Severe overtaper Undercut Severe B / L path of draw
D. Axial line angles	Reduction provides 1.0mm margin at facial and 0.5mm at lingual line angles 6-8° per wall	Slightly over / under reduced -overtapered	Moderately over / under reduced -overtapered Tight (<6°)	Severe over / under reduction -overtaper Undercut
E. Lingual wall height	Lingual wall height 1.5 mm minimum	Slightly less than 1.5mm high	Moderately less than 1.5mm high	Severely less than 1.5mm high
F. Axial wall smoothness	Walls smooth	Walls slightly rough	Walls moderately rough	Walls severely rough

GRADE 82

Specification:	Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
A. Axial reduction	M/D width of prep approx 5mm 1.0mm margin at facial 0.5mm margin at lingual line angle	Slightly over / under reduced	Moderately over / under reduced	Severely over / under reduced
B. Occlusal convergence	6-8° per wall Path of draw	Slight overtaper Slight M / D path of draw	Moderate overtaper Tight (<6° per wall) Moderate M / D path of draw	Severe overtaper Undercut Severe M / D path of draw
C. Plane of reduction	Flat Not undercut		Wall barreled slightly	Wall barreled moderately / severely Undercut
D. Axial wall height	M/D wall height 4mm minimum	Slightly less than 4.0mm high	Moderately less than 4.0mm	Severely less than 4.0mm high
E. Gingival margin clearance with opposing tooth	1mm minimum			No clearance
F. Adjacent tooth damage	See Treatment Management			

GRADE 91

2. Proximal Reduction

Specification:	Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
A. Reduction	Incisal 2-2.5mm Lingual slope 1mm	Slightly over / under reduced	Moderately over / under reduced	Severely over / under reduced
B. Uniformity and line angles	All angles rounded Flat lingual slope	Slightly sharp angles -rough -concave lingual slope M/D	Moderately sharp angles -rough -concave lingual slope M/D	Severely sharp angles -rough -concave lingual slope M/D
C. Incisal edge thickness and angle of reduction	Thickness 0.5-0.75 mm Lingual angle of reduction	Slightly <0.5 or >0.75 mm thick -flat or steep angle of reduction	Moderately <0.5 or >0.75 mm thick -flat or steep angle of reduction	Severely <0.5 or >0.75 mm thick -flat or steep angle of reduction

GRADE 65

Specification:	Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
A. Margin width	Facial: 1.0mm wide rounded shoulder Lingual: 0.5mm chamfer Facial and lingual margins blend smoothly in interproximal area	Facial / Lingual: slightly thin / wide	Facial / Lingual: moderately thin / wide	Facial / Lingual: extremely thin / wide
B. Margin definition and extension	Smooth 0.3-0.5mm above gingival crest	Slightly rough margin ->0.5mm or <0.3mm above gingival crest	Moderately rough margin ->0.5mm or <0.3mm above gingival crest	Extremely rough margin ->0.5mm above gingival crest
C. Cavo surface angle	110° optimal	Slightly steep (>110°)	Moderately steep (>110°)	Margin tipped (>110°) Margin beveled
D. Axial wall finish	Smooth axial surfaces	Slightly rough axial surfaces	Moderately rough axial surfaces	Severely rough axial surfaces

GRADE 65

Specification:	Standard	-1-5 Points	-5-10 Points	-10-15 Points
A. Condition of adjacent teeth	No damage	Slight damage that can be removed with polishing	Moderate damage that changes contact shape and position	Gross damage which would require a restoration
B. Soft tissue condition	Margin 0.3-0.5mm above gingival crest with no damage	Slight damage to gingival crest	Moderate damage to gingival crest	Gross gingival damage
C. Dentoform cleanliness Bar removed	Dentoform clean Bar removed	Dentoform dirty Bar not removed		
D. Dentoform occlusion	Teeth tight Occlusion stable	Loose teeth Slight occlusal discrepancy	Moderate occlusal discrepancy	Severe occlusal discrepancy
E. Critical errors	Correct tooth treated			Wrong tooth treated
F. Operating/ patient position	Correct operating and patient position	Number of observed second infractions		

TOTAL -3

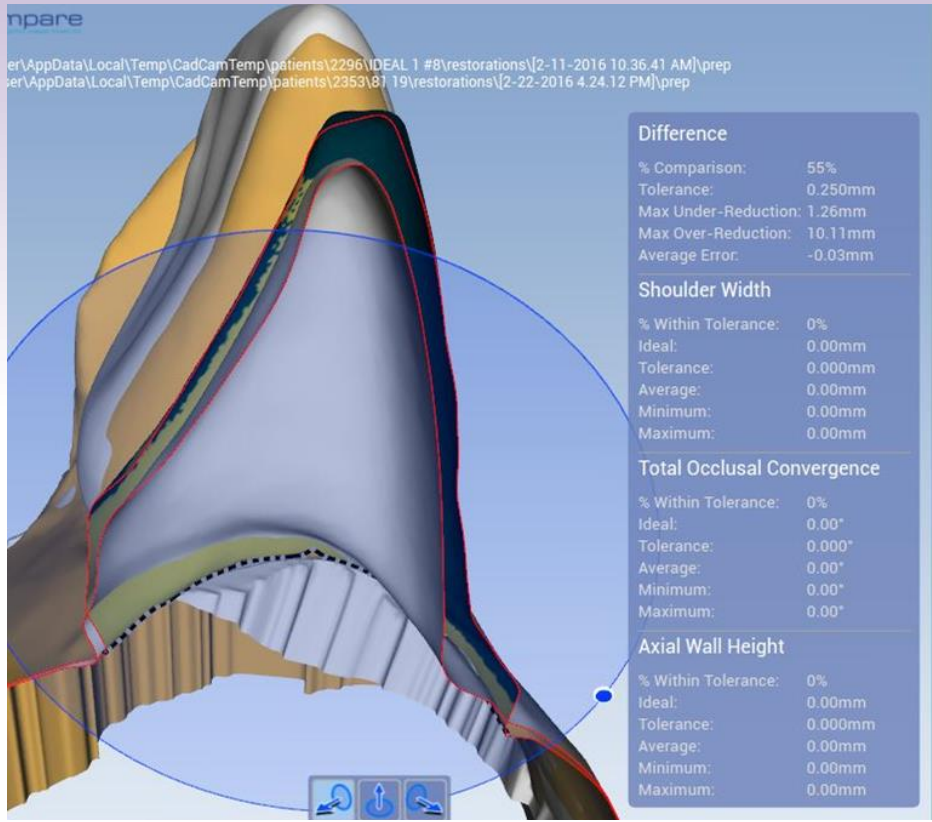
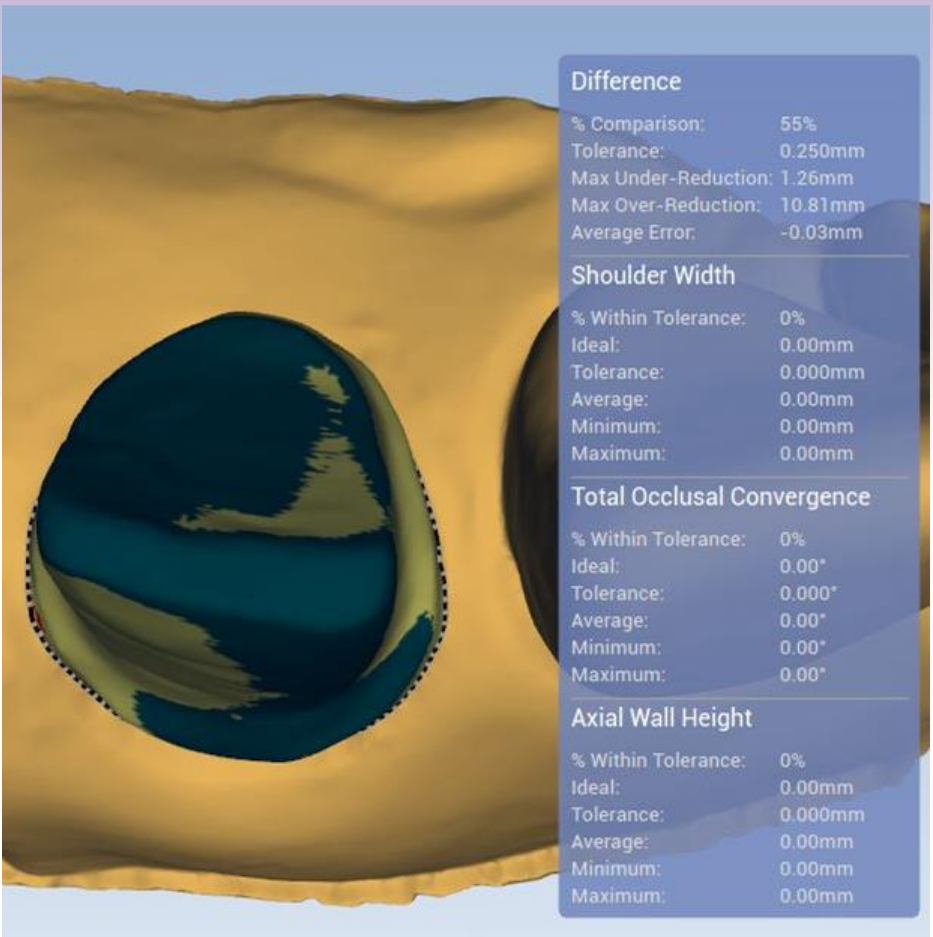
5. Treatment Management

3

Dentiform# 19		Major Deviation/ Critical Error	Moderate Deviation	Minor Deviation	No Deviation	TOTAL
1 OVER Reduction						0
MM -Incisal/lingual slope		'0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10				
RC -Facial/lingual		'0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10				
KJ -Mesial/distal		'0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10				
2 UNDER Reduction						0
MM -Incisal/lingual slope		'0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10				
RC -Facial/lingual		'0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10				
KJ -Mesial/distal		'0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10				
3 OVERTaper						0
RC -Facial/lingual		'0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10				
KJ -Mesial/distal		'0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10				
4 Draw (tight/undercut)						8
RC -Facial/lingual		'0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10				
KJ -Mesial/distal		'0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10				
5 Margins						1
VH -Width, definition, extension, finish		'0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10				
VH -Cavosurface angle		'0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10				
6 Damage and Neatness						7
KJ -Adjacent teeth		'0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10				
VH -Soft tissue		'0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10				
*** -Dentiform dirty, bar		'0 - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10				
6 E4D % Comparison						

TOTAL 28





Specification:		Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
1. Facial-Lingual Reduction	A. Axial wall reduction	Facial: 1.0 mm at margin, 1.5mm mid-facial to incisal Lingual provides 0.5mm margin	Slightly over / under reduced	Moderately over / under reduced	Severely over / under reduced
	B. Axial wall plane of reduction	Facial follows labial surface M/D Lingual: flat preparation wall	Slight deviation of facial surface Lingual slightly barrelled	Moderate deviation of facial surface Lingual moderately barrelled	Severe deviation of facial surface Lingual severely barrelled
	C. Occlusal convergence	6-8° per wall Appropriate path of draw	Slight -over / undertaper -B / L path of draw	Moderate overtaper Tight (<6° per wall) Moderate B / L path of draw	Severe overtaper Undercut Severe B / L path of draw
	D. Axial line angles	Reduction provides 1.0mm margin at facial and 0.5mm at lingual line angles 6-8° per wall	Slightly -over / under reduced -overtapered	Moderately -over / under reduced -overtapered Tight (<8°)	Severe -over / under reduction -overtaper Undercut
	E. Lingual wall height	Lingual wall height 1.5 mm minimum	Slightly less than 1.5mm high	Moderately less than 1.5mm	Severely less than 1.5mm high
	F. Axial wall smoothness	Walls smooth	Walls slightly rough	Walls moderately rough	Walls severely rough
GRADE					88

Specification:		Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
2. Proximal Reduction	A. Axial reduction	M/D width of prep approx 5mm 1.0mm margin at facial 0.5mm margin at lingual line angle	Slightly -over / under reduced	Moderately -over / under reduced	Severely -over / under reduced
	B. Occlusal convergence	6-8° per wall Path of draw	Slight overtaper Slight M / D path of draw	Moderate overtaper Tight (<6° per wall) Moderate M / D path of draw	Severe overtaper Undercut Severe M / D path of draw
	C. Plane of reduction	Flat Not undercut		Wall barrelled slightly	Wall barrelled moderately /severely Undercut
	D. Axial wall height	M/D wall height 4mm minimum	Slightly less than 4.0mm high	Moderately less than 4.0mm	Severely less than 4.0mm high
	E. Gingival margin clearance with opposing tooth	1mm minimum			No clearance
	F. Adjacent tooth damage	See Treatment Management			
GRADE					99

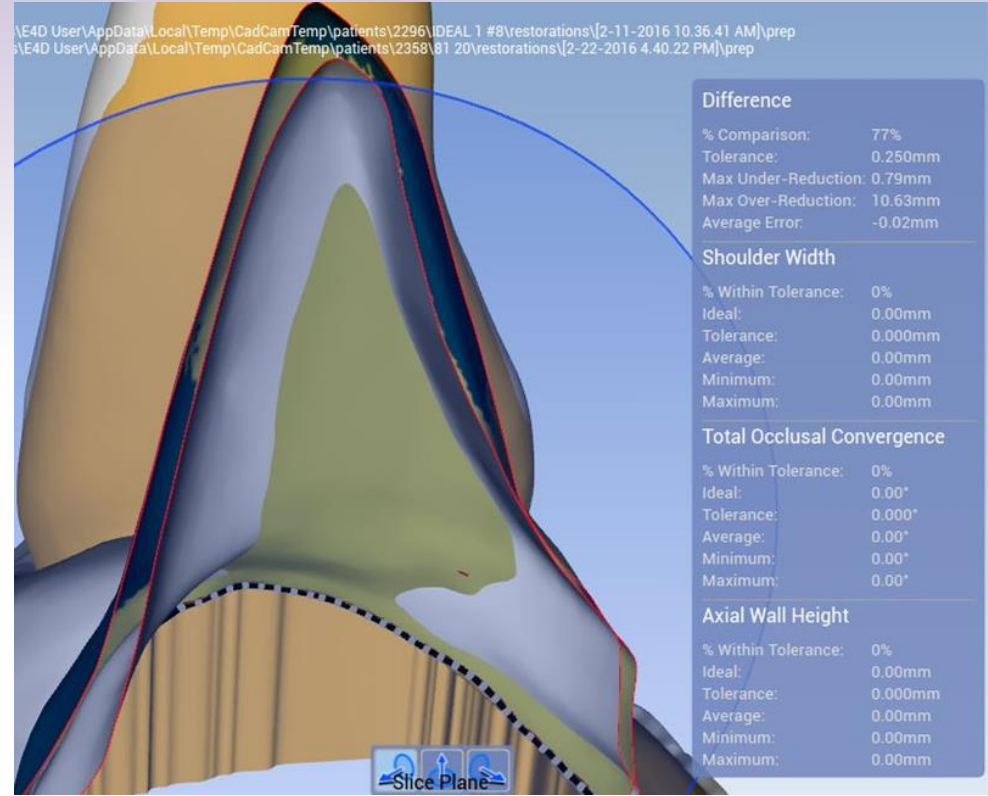
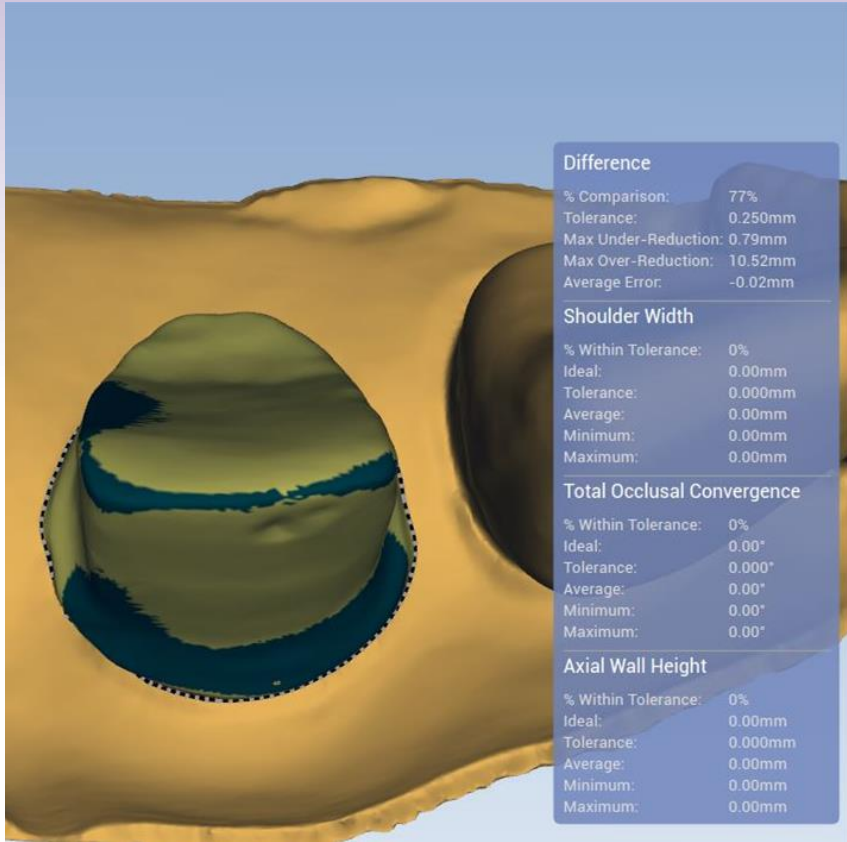
Specification:		Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
3. Incisal / Lingual Slope Reduction	A. Reduction	Incisal 2-2.5mm Lingual slope 1mm	Slightly over / under reduced	Moderately over / under reduced	Severely over / under reduced
	B. Uniformity and line angles	All angles rounded Flat lingual slope	Slightly -sharp angles -rough -concave lingual slope M/D	Moderately -sharp angles -rough -concave lingual slope M/D	Severely -sharp angles -rough -concave lingual slope M/D
	C. Incisal edge thickness and angle of reduction	Thickness 0.5-0.75 mm Lingual angle of reduction	Slightly -0.5 or >0.75 mm thick -flat or steep angle of reduction	Moderately -<0.5 or >0.75 mm thick -flat or steep angle of reduction	Severely -<0.5 or >0.75 mm thick -flat or steep angle of reduction
GRADE					82

Specification:		Standard	Minor Deviation	Moderate Deviation	Major Deviation Critical Error
4. Margins and Finish	A. Margin width	Facial: 1.0mm wide rounded shoulder Lingual: 0.5mm chamfer Facial and lingual margins blend smoothly in interproximal area	Facial / Lingual: slightly thin / wide Facial and lingual walls do not blend smoothly slightly F / L	Facial / Lingual: moderately thin / wide Facial and lingual walls do not blend smoothly moderately F / L	Facial / Lingual: extremely wide Slice margin (0mm width) Facial and lingual walls do not blend smoothly severely
	B. Margin definition and extension	Smooth 0.3-0.5mm above gingival crest	Slightly -rough margin ->0.5mm or <0.3mm above gingival crest	Moderately -rough margin ->0.5mm or <0.3mm above gingival crest	Extremely -rough margin ->0.5mm above gingival crest
	C. Cavosurface angle	110° optimal	Slightly steep (>110°)	Moderately steep (>110°)	Margin tipped (<110°) Margin beveled
	D. Axial wall finish	Smooth axial surfaces	Slightly rough axial surfaces	Moderately rough axial surfaces	Severely rough axial surfaces
GRADE					70

Specification:		Standard	-1 -5 Points	-5-10 Points	-10-15 Points
5. Treatment Management	A. Condition of adjacent teeth	No damage	Slight damage that can be removed with polishing	Moderate damage that changes contact shape and position	Gross damage which would require a restoration
	B. Soft tissue condition	Margin 0.3-0.5mm above gingival crest with no damage	Slight damage to gingival crest	Moderate damage to gingival crest	Gross gingival damage
	C. Dentoforn cleanliness Bar removed	Dentoforn clean Bar removed	Dentoforn dirty Bar not removed		
	D. Dentoforn occlusion	Teeth tight Occlusion stable	Loose teeth Slight occlusal discrepancy	Moderate occlusal discrepancy	Severe occlusal discrepancy
	E. Critical errors	Correct tooth treated			Wrong tooth treated
	F. Operating/patient position	Correct operating and patient position	Number of observed second infractions		
Penalty Points			TOTAL		
			0		

Dentiform# 20		Major Deviation/ Critical Error	Moderate Deviation	Minor Deviation	No Deviation	TOTAL
<b>1 OVER Reduction</b>						<b>10</b>
MM -Incisal/lingual slope		0-1-2-3-4-5-6-7-8-9-10				
RC -Facial/lingual		0-1-2-3-4-5-6-7-8-9-10			10	
KJ -Mesial/distal		0-1-2-3-4-5-6-7-8-9-10			10	
<b>2 UNDER Reduction</b>						<b>5</b>
MM -Incisal/lingual slope		0-1-2-3-4-5-6-7-8-9-10				
RC -Facial/lingual		0-1-2-3-4-5-6-7-8-9-10			8	
KJ -Mesial/distal		0-1-2-3-4-5-6-7-8-9-10			10	
<b>3 OVERTaper</b>						<b>9</b>
RC -Facial/lingual		0-1-2-3-4-5-6-7-8-9-10			10	
KJ -Mesial/distal		0-1-2-3-4-5-6-7-8-9-10			9	
<b>4 Draw (tight/undercut)</b>						<b>10</b>
RC -Facial/lingual		0-1-2-3-4-5-6-7-8-9-10			10	
KJ -Mesial/distal		0-1-2-3-4-5-6-7-8-9-10			10	
<b>5 Margins</b>						<b>3</b>
VH -Width, definition, extension, finish		0-1-2-3-4-5-6-7-8-9-10			6	
VH -Cavosurface angle		0-1-2-3-4-5-6-7-8-9-10			3	
<b>6 Damage and Neatness</b>						<b>10</b>
KJ -Adjacent teeth		0-1-2-3-4-5-6-7-8-9-10			10	
VH -Soft tissue		0-1-2-3-4-5-6-7-8-9-10			10	
*** -Dentiform dirty, bar		0-1-2-3-4-5-6-7-8-9-10			10	
<b>6 E4D % Comparison</b>						

TOTAL **47**



# Faculty/New

## → Nonparametric Correlations

Correlations

		Faculty	New		
Spearman's rho	Faculty	Correlation Coefficient	1.000	.847**	
		Sig. (2-tailed)	.	.000	
		N	81	81	
	Bootstrap <sup>b</sup>	Bias		.000	-.004
			Std. Error	.000	.038
		95% Confidence Interval	Lower	1.000	.757
			Upper	1.000	.908
		New	Correlation Coefficient	.847**	1.000
	Sig. (2-tailed)		.000	.	
	N		81	81	
Bootstrap <sup>b</sup>	Bias		-.004	.000	
	Std. Error		.038	.000	
95% Confidence Interval	Lower		.757	1.000	
	Upper		.908	1.000	

\*\* . Correlation is significant at the 0.01 level (2-tailed).

b. Unless otherwise noted, bootstrap results are based on 81 bootstrap samples



# Subjective Faculty Grade vs. New

## “60% Subj. Faculty Grade + 40% Compare 250”

Correlations			Faculty Exam Percentage Total	Faculty/CompareTotal (60/40)
Faculty Exam Percentage Total	Pearson Correlation		1	.917**
	Sig. (2-tailed)			.000
	N		67	67
Faculty/CompareTotal (60/40)	Pearson Correlation		.917**	1
	Sig. (2-tailed)		.000	
	N		67	67

\*\* . Correlation is significant at the 0.01 level (2-tailed).

# Faculty/E4D Compare

## ➔ Nonparametric Correlations

Correlations

		Faculty	E4D		
Spearman's rho	Faculty	Correlation Coefficient	1.000	.503**	
		Sig. (2-tailed)	.	.000	
		N	81	81	
	Bootstrap <sup>c</sup>	Bias		.000	-.029
			Std. Error	.000	.092
		95% Confidence Interval	Lower	1.000	.308
			Upper	1.000	.668
		E4D	Correlation Coefficient	.503**	1.000
	Sig. (2-tailed)		.000	.	
	N		81	81	
Bootstrap <sup>c</sup>	Bias		-.029	.000	
	Std. Error		.092	.000	
95% Confidence Interval	Lower		.308	1.000	
	Upper		.668	1.000	

\*\* Correlation is significant at the 0.01 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 81 bootstrap samples

# Faculty/Combined Rubric

**Correlations**

		Faculty	Combined		
Faculty	Pearson Correlation	1	.860**		
	Sig. (2-tailed)		.000		
	N	81	81		
	Bootstrap <sup>b</sup>	Bias	0	.000	
		Std. Error	0	.031	
		95% Confidence Interval	Lower	1	.783
			Upper	1	.908
Combined	Pearson Correlation	.860**	1		
	Sig. (2-tailed)	.000			
	N	81	81		
	Bootstrap <sup>b</sup>	Bias	.000	0	
		Std. Error	.031	0	
		95% Confidence Interval	Lower	.783	1
			Upper	.908	1

\*\* . Correlation is significant at the 0.01 level (2-tailed).

b. Unless otherwise noted, bootstrap results are based on 81 bootstrap samples

# Subjective Faculty Grade vs. 60% Subj. Faculty Grade + 40% Compare 250

Correlations			
		Faculty Exam Percentage Total	Faculty/CompareTotal (60/40)
Faculty Exam Percentage Total	Pearson Correlation	1	.917**
	Sig. (2-tailed)		.000
	N	67	67
Faculty/CompareTotal (60/40)	Pearson Correlation	.917**	1
	Sig. (2-tailed)	.000	
	N	67	67

\*\* . Correlation is significant at the 0.01 level (2-tailed).

# Subjective Faculty Grade vs. Faculty Outline/Cavosurface + Compare 250

Correlations					
		Faculty Exam Percentage Total	Subjective/Co mpareTotal Raw(60/40)	Subjective/Co mpareTotal Raw(75/25)	Subjective/Co mpareTotal Raw (80/20)
Faculty Exam	Pearson	1	.800**	.821**	.822**
Percentage Total	Correlation				
	Sig. (2-tailed)				
	N	67	67	67	67

\*\* . Correlation is significant at the 0.01 level (2-tailed).

# Faculty Internal/Retention vs. Compare 250 Score

**Descriptive Statistics**

	Mean	Std. Deviation	N
250	54.254	9.0124	67
Faculty Internal Retention (50/50)	65.970	14.3875	67

**Correlations**

		250	Faculty Internal Retention (50/50)
250	Pearson Correlation	1	.341**
	Sig. (2-tailed)		.005
	N	67	67
Faculty Internal Retention (50/50)	Pearson Correlation	.341**	1
	Sig. (2-tailed)	.005	
	N	67	67

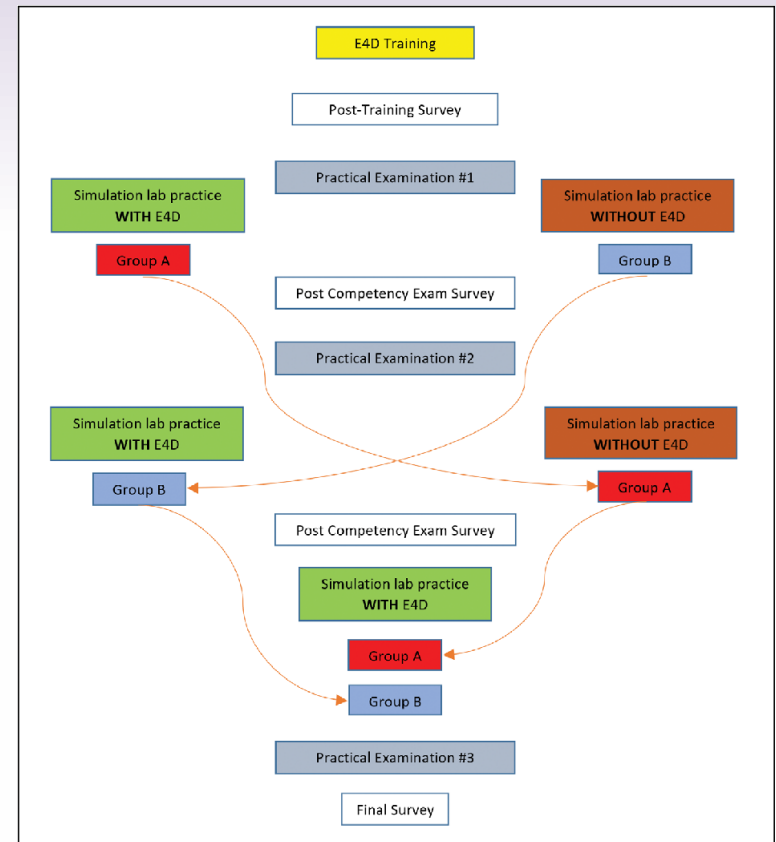
\*\* . Correlation is significant at the 0.01 level (2-tailed).



# Effectiveness and Feasibility of Utilizing E4D Technology as a Teaching Tool in a Preclinical Dental Education Environment

Richard S. Callan, D.M.D., Ed.S.; Christie L. Palladino, M.D., M.Sc.;  
Alan R. Furness, D.M.D.; Emily L. Bundy, D.M.D.; Brittany L. Ange, M.S.

Even so, when given the opportunity to utilize the technology in preparation for the competency exam, surprisingly few students participated. The actual utilization rates (Table 5) were much less than one might anticipate and much lower than the percentage of students indicating interest on the surveys. We should emphasize that participation in this study was voluntary as was the amount of time each student spent using the technology when it was made available. Anecdotally, faculty members working in the simulation lab noted that students were more apt to request feedback from the specific professor who would be grading the competency exam than to visualize the difference themselves utilizing the E4D technology. This may suggest students were



# Where Do We Go From Here?

- Integrate throughout all years of dental curriculum.
  - D1 introduction, dental anatomy, wax ups
  - D2 fixed prosthodontics
- Make available 24/7 to promote objective feedback following rotations
- Is there potential for objective grades?
- Is there a Magic formula?!

*Thank You*

**THE DENTAL COLLEGE OF GEORGIA**

