Comparison between Conventional Visual and a Novel Digital Technique to Grade Dental Anatomy Projects

So Ran Kwon, DDS, MS, PhD, MS
Department of Operative Dentistry
University of Iowa College of Dentistry & Dental Clinics

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THE UNIVERSITY OF IOWA

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- Co-authors: Natalia Restrepo-Kennedy, DDS, MS
  Deborah V. Dawson, PhD, Sc.M
  Marcela Hernandez, DDS, MS
  Gerald Denehy, DDS, MS
  Derek Blanchette, BA, MS
  David Gratton, DDS, MS
  Steve Aquilino, DDS, MS
  Steven R. Armstrong, DDS, PhD, FADM

The University of Iowa

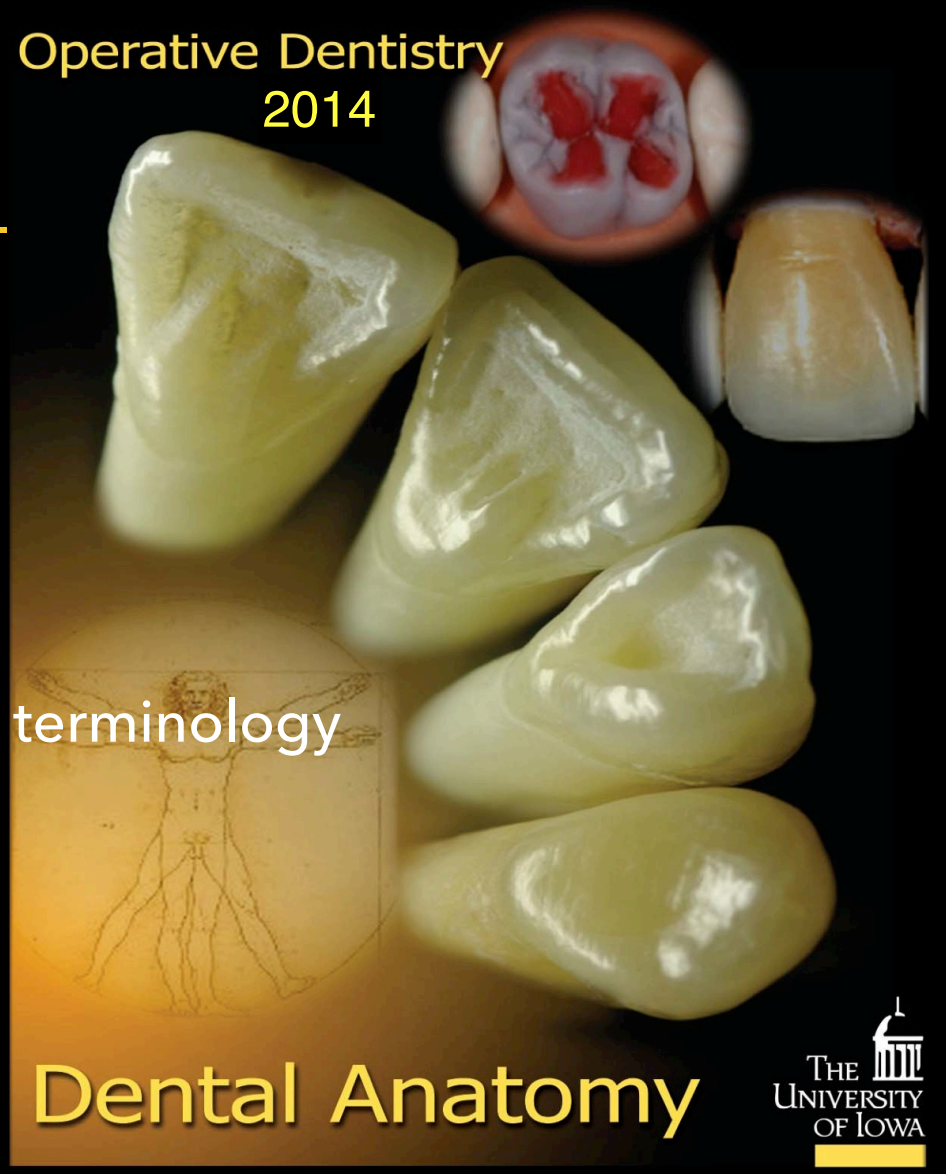
Dental Anatomy

The study of the development, morphology, function, and identity of teeth in the human dentitions, as well as the way in which they relate in shape, form, structure, color, and function to the teeth in the same dental arch and to the opposing arch.

Wheeler's Dental Anatomy, Physiology, and Occlusion-Nelson and Ash

Dental Anatomy at UI

- 12 weeks course for freshmen
- Complete 4 full tooth waxing projects (#9, 4, 14 & 19)
- Knowledge of dental anatomy and terminology
- Psychomotor skills
- Self-evaluation skills



Visual Evaluation

- Evaluation using pre-established check list
- Subjective evaluation
- Intra/Inter rater reliability
- Students' feedback

(Lilley et al, 1968; Jenkins et al, 1998; Haj-Ali et al, 2006; Sharaf et al, 2007)

Check-list for Dental Anatomy Grading

Evaluator name:

Evaluation date and time:

Dentoform Random Number:

Contact, line angle & embrasure	**CORRECT**	**ERROR**
Mesial contact	visual contact, correct width and position	wide narrow too occlusal too gingival too facial too lingual irregular light missing
Distal contact	visual contact, correct width and position	wide narrow open wrong location too facial too lingual irregular light missing
MB embrasure MB line angle	normal contour normal position and shape	closed open irregular malpositioned sharp rounded
MO embrasure	normal contour	closed open irregular point angle sharp-round
MG embrasure	normal contour	closed open irregular
DB embrasure DB line angle	normal contour normal position and shape	closed open irregular malpositioned sharp rounded
DO embrasure	normal contour	closed open irregular point angle sharp-round
DG embrasure	normal contour	closed open irregular
ML embrasure ML line angle	normal contour normal position and shape	closed open irregular malpositioned sharp rounded
DL embrasure DL line angle	normal contour normal position and shape	closed open irregular malpositioned sharp rounded

F & L contours, cusps & grooves		
Buccal contour, M-D	normal contour	convex concave flat irregular
Buccal contour, O-G	normal contour	convex concave flat irregular
Lingual contour, M-D	normal contour	convex concave flat irregular
Lingual contour, O-G	normal contour	convex concave flat irregular
MB cusp	correct height, position and shape	facial lingual mesial distal high low sharp rounded flat slopes concave slopes wrong slopes
DB cusp	correct height, position and shape	facial lingual mesial distal high low sharp rounded flat slopes concave slopes wrong slopes
ML cusp	correct height, position and shape	facial lingual mesial distal high low sharp rounded flat slopes concave slopes wrong slopes
DL cusp	correct height, position and shape	facial lingual mesial distal high low sharp rounded flat slopes concave slopes wrong slopes
Buccal groove	correct position, length, depth and slant	mesial distal long short shallow deep wrong slant
Distolingual groove	correct position, length, depth and slant	mesial distal long short shallow deep wrong slant

Occlusal anatomy & surface finish		
Mesial marginal ridge	proper height, width and well-defined	too mesial too distal too high too low wrong slant too wide too narrow too sharp
Distal marginal ridge	proper height, width and well-defined	too mesial too distal too high too low wrong slant too wide too narrow too sharp
Triangular ridges	correct shape, slope and position	flat rounded sharp wrong shape not defined inclined too steeply incline not steep enough too mesial too distal
Oblique ridge	correct shape, slope and position	flat rounded sharp wrong shape not defined inclined too steeply incline not steep enough too mesial too distal
Primary grooves (MB&DL)	correct position and depth	not defined shallow deep wrong position
Secondary grooves	correct position and depth	not defined shallow deep wrong position
Fossae	correct position, shape and depth	shallow deep wide narrow
Surface finish	smooth, shiny, free of pits and scratches	dull pitted scratched irregular not blended

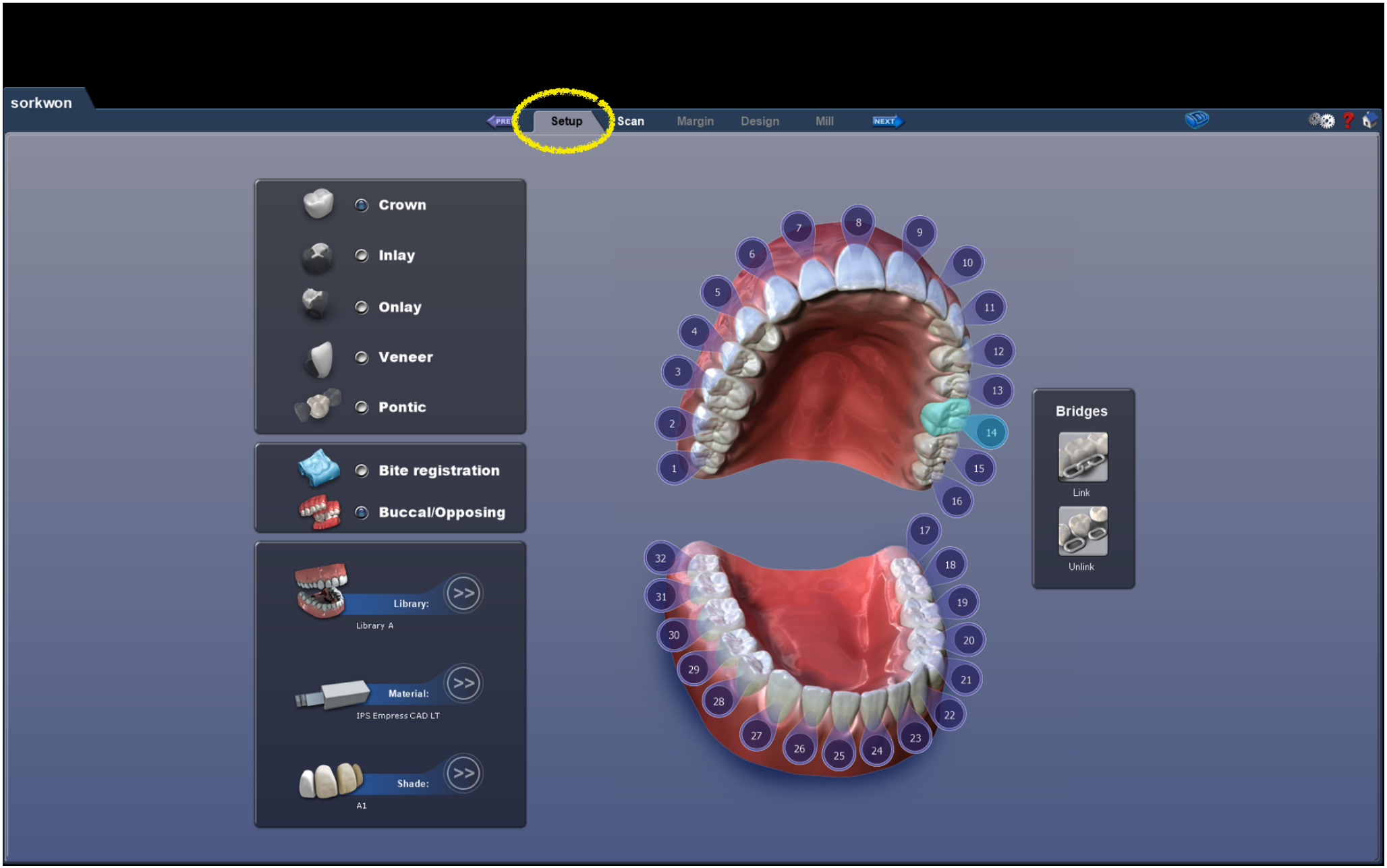
Total Score	20	8

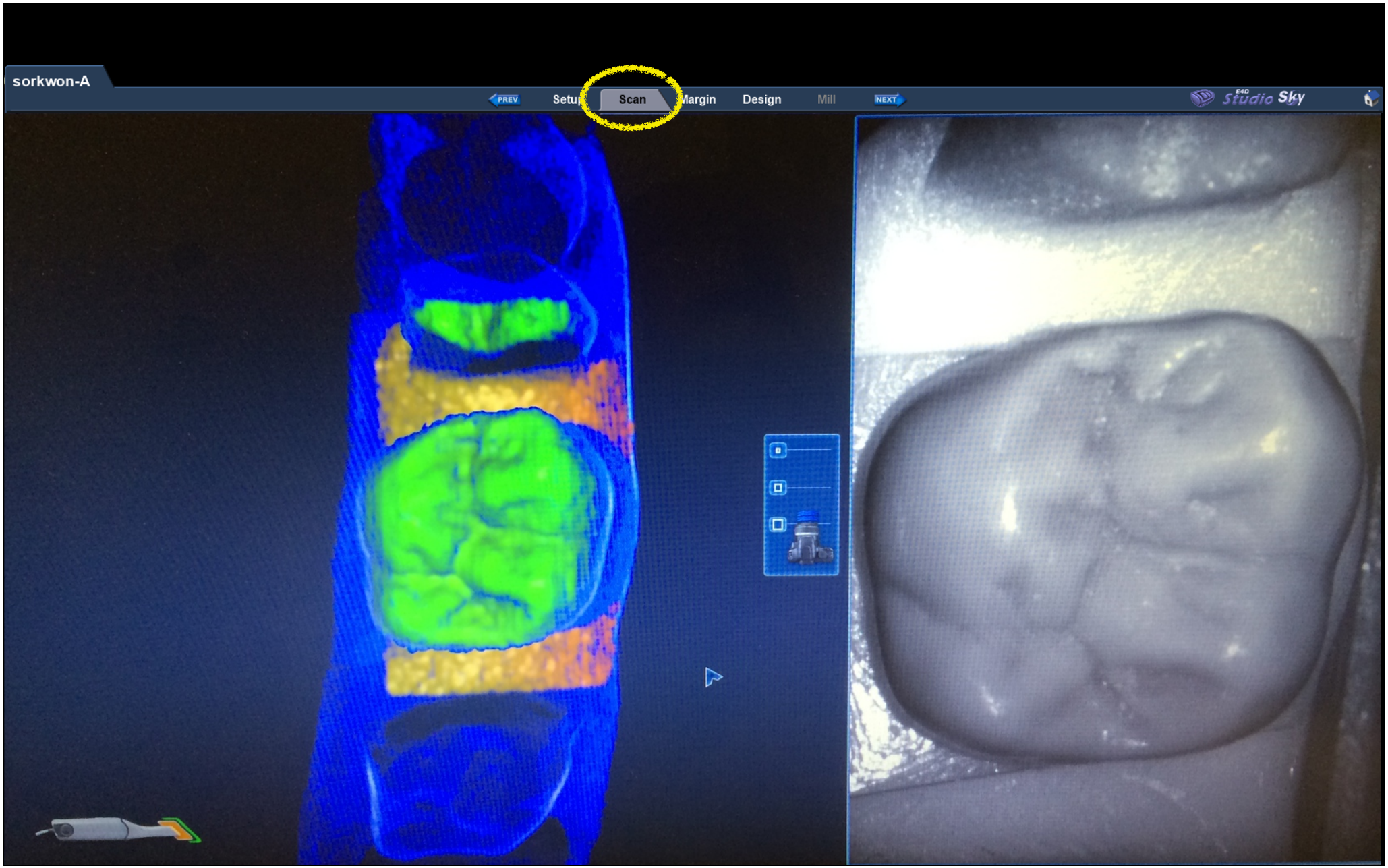
20÷28x100=71.43

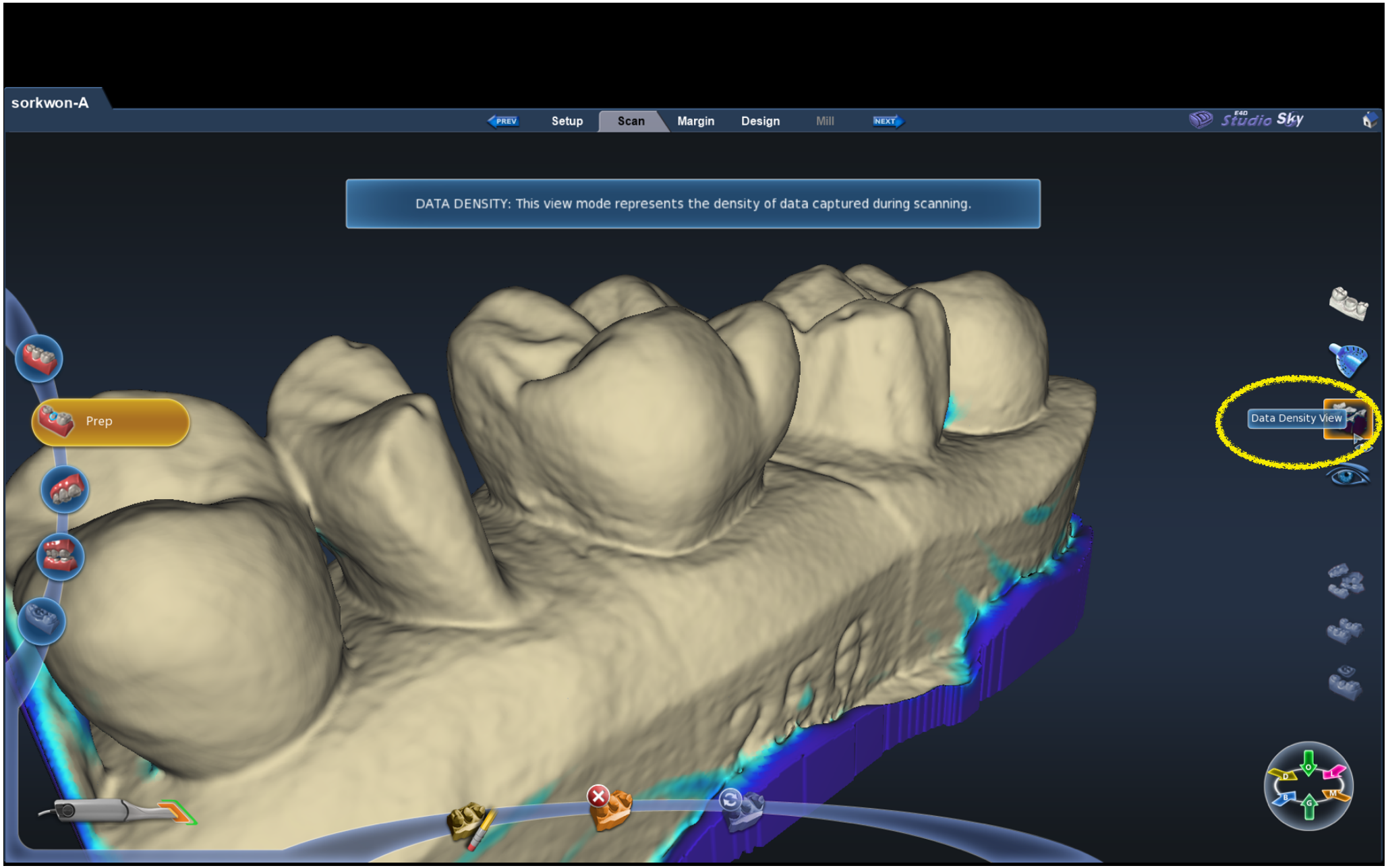
Digital Evaluation

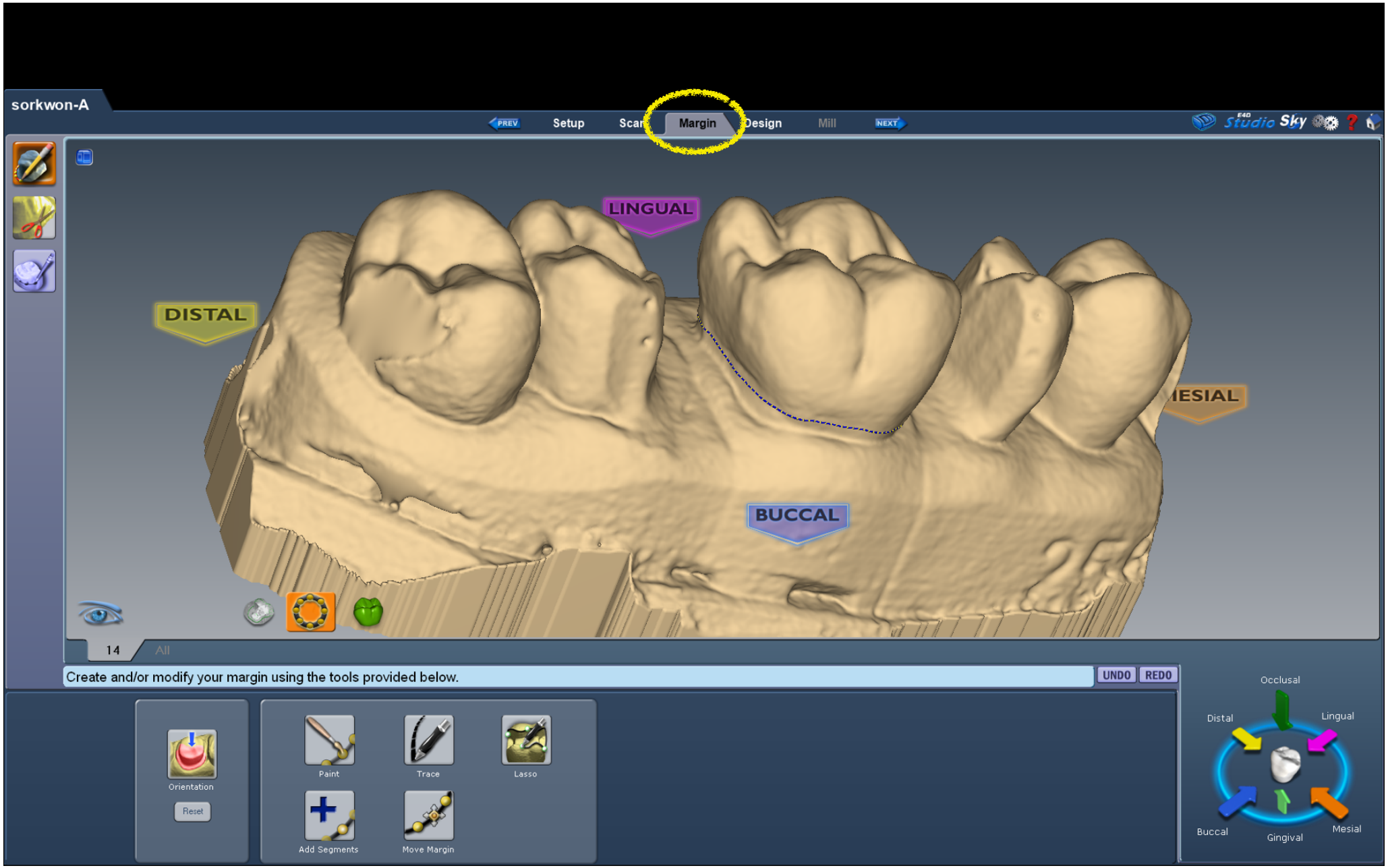
- CEREC prepcheck, E4D Compare
- Objective evaluation
- Evaluation using scanned model compared to master model
- Students' feedback

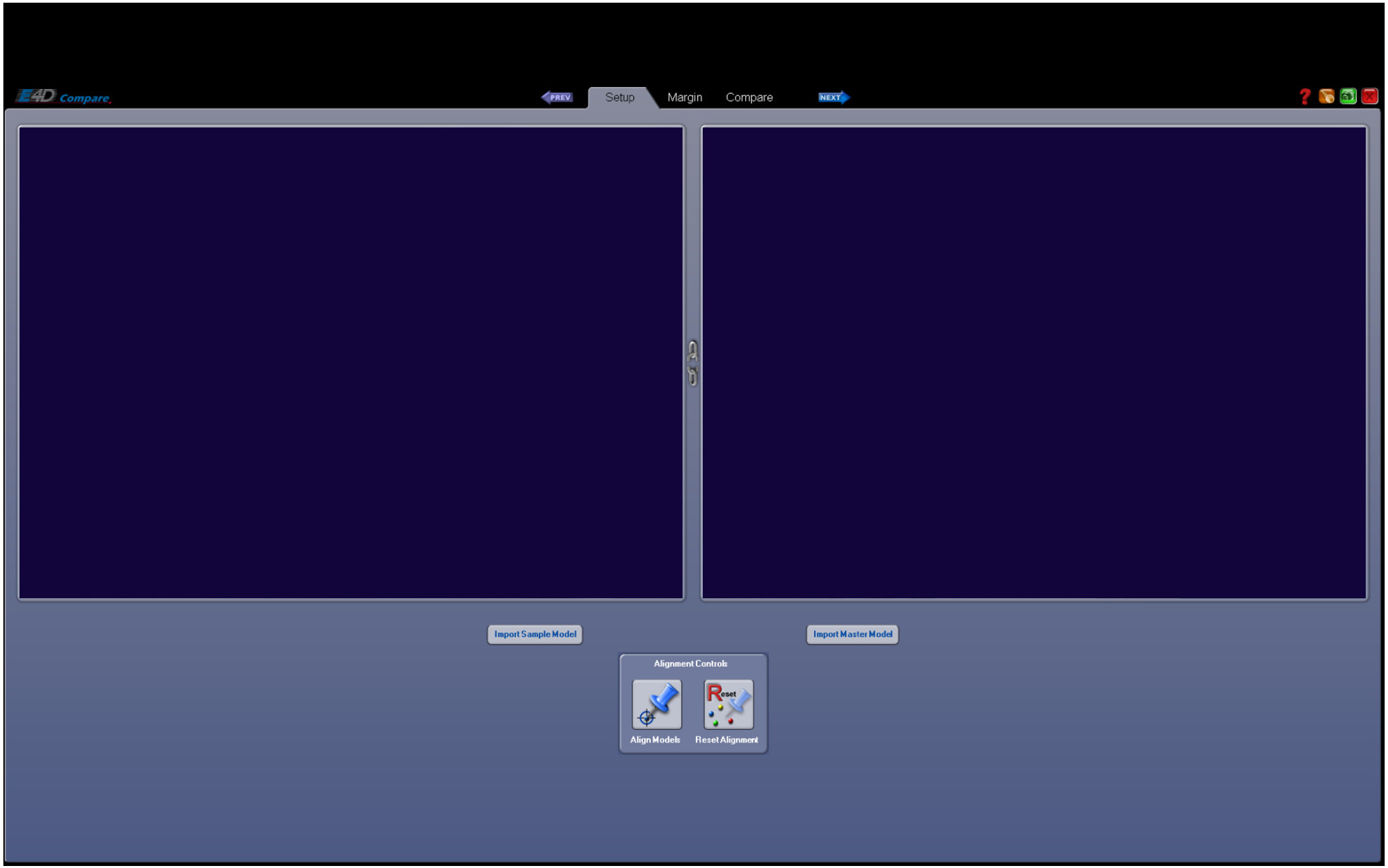
Renne et al. E4D Compare Software: An Alternative to Faculty Grading in Dental Education JDE, 2013

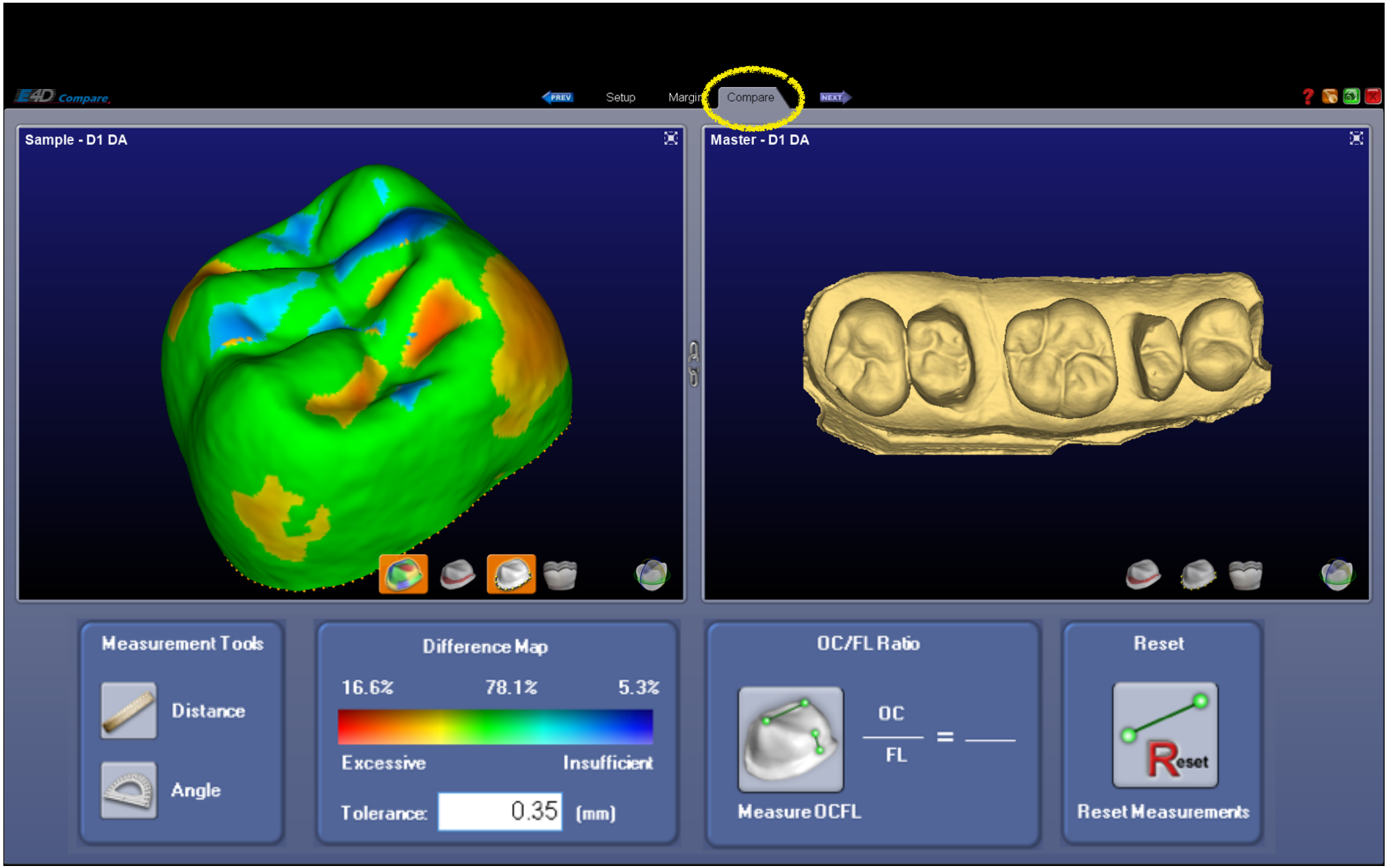

sorkwon
Setup
Scan
Margin
Design
Mill
Crown
Inlay
Onlay
Veneer
Pontic
Bite registration
Buccal/Opposing
Library:
Library A
Material:
IPS Empress CAD LT
Shade:
A1
Bridges
Link
Unlink


sorkwon-A
PREV
Setup
Scan
Margin
Design
Mill
NEXT
E4D Studio Sky


sorkwon-A
PREV
Setup
Scan
Margin
Design
Mill
NEXT
E4D Studio Sky
DATA DENSITY: This view mode represents the density of data captured during scanning.
Prep
Data Density View


sorkwon-A
PREV
Setup
Scan
Margin
Design
Mill
NEXT
LINGUAL
DISTAL
BUCCAL
14
All
Create and/or modify your margin using the tools provided below.
UNDO
REDO
Orientation
Reset
Paint
Trace
Lasso
Add Segments
Move Margin
Occlusal
Distal
Lingual
Buccal
Gingival
Mesial


E4D Compare
PREV
Setup
Margin
Compare
NEXT
Import Sample Model
Import Master Model
Alignment Controls
Align Models
Reset
Reset Alignment


E4D Compare
PREV
Setup
Margin
Compare
NEXT
Sample - D1 DA
Master - D1 DA
Measurement Tools
Distance
Angle
Difference Map
16.6%
78.1%
5.3%
Excessive
Insufficient
Tolerance:
0.35
(mm)
OC/FL Ratio
OC
FL
=
Measure OCFL
Reset
Reset
Reset Measurements

Visual vs Digital

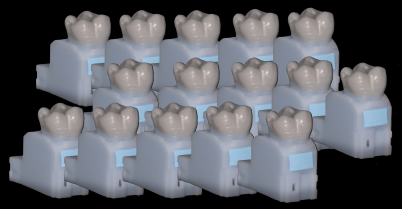
- Intra/Inter rater reliability in dental anatomy visual grading
- Intra rater reliability of digital grading
- Time required for grading
- Correlation between visual and digital grading
- Master model validation/selection process

Purpose

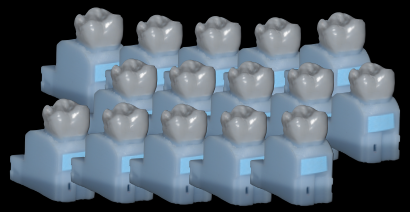
- Compare visual grading performed by two evaluators to digital grading by one operator
- Establish a decision making process to validate the selection of the master model
- Determine the proper tolerance level for digital grading in the dental anatomy course

Materials & Methods

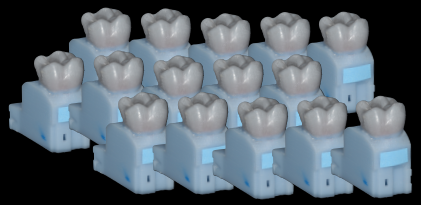
Faculty A



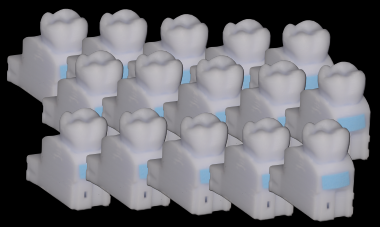
Faculty B



Students



Dentoform



Visual Grading (Trial 1 & Trial 2) Faculty 1 & Faculty 2

Digital Grading (Trial 1 & Trial 2) Operator 1

Data Analysis

Waxing of tooth #14

- Two faculty (A & B) involved in teaching the dental anatomy course
- 15 wax-ups according to guidelines given in 2013 University of Iowa Dental Anatomy Manual
- Maximum allowed time was limited to 3 hours per wax-up
- Blue dental model (Lava model, 3M ESPE)-replica of KaVo basic study model (KaVo Dental)

Sample Wax-ups for Grading

- Total of 60 samples
- Faculty A & B (n=30)
- Randomly selected freshmen dental student wax-ups (n=15)
- Dentoform tooth #14 (n=15)

Visual Grading

- Faculty 1 & 2
- One-hour calibration session
- Wax-ups were graded independently on a 28 point scale and converted to a percentage grade
- Visual grading was repeated after one week

Digital Grading

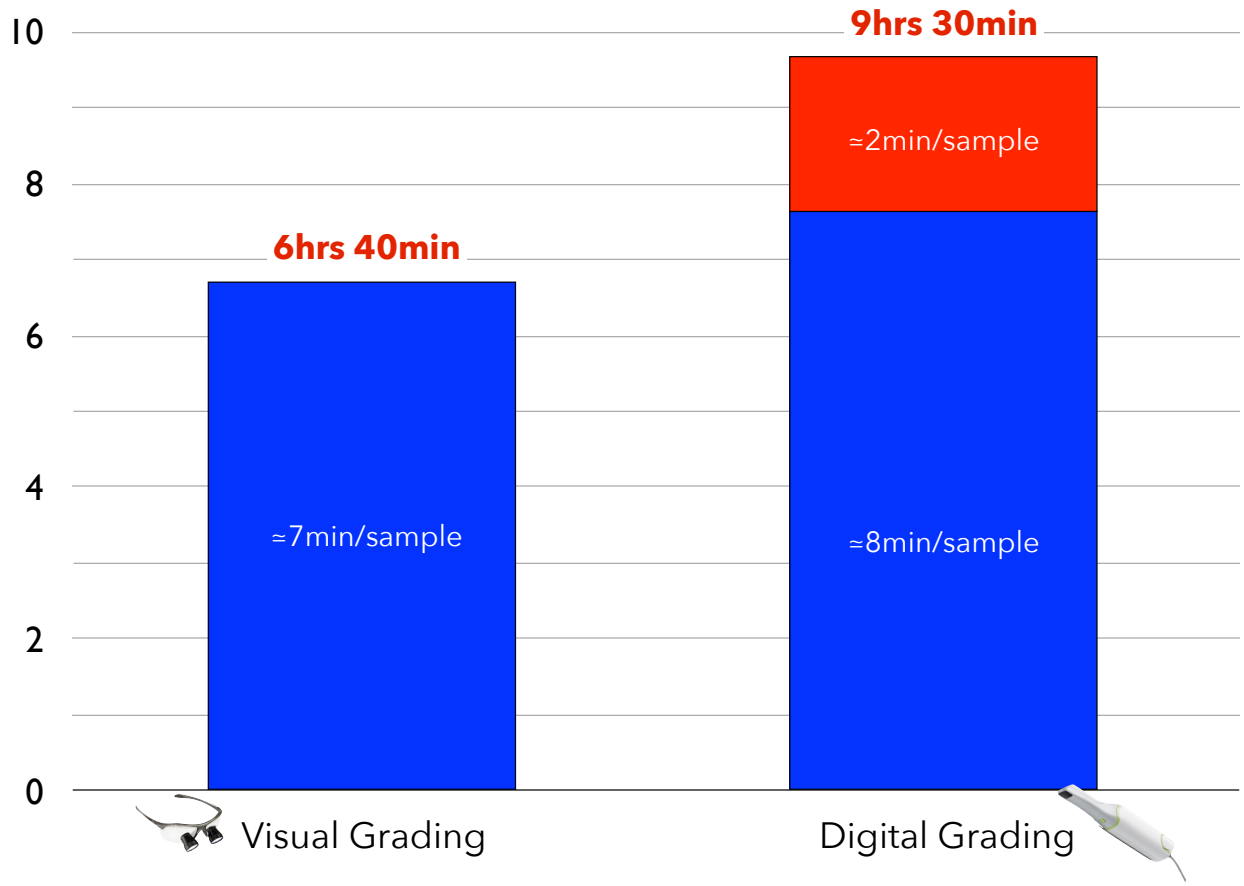
- Operator 1
- Master model based on highest score from visual grading
- E4D Nevo laser scanner & E4D Compare software (E4D Technologies) Tolerance level: 0.25, 0.30, 0.35mm
- Digital grading was repeated after one week

Statistical Analysis

- Descriptive statistics and signed rank test for systematic bias were used for intra- and inter-rater comparisons
- Intraclass correlation (ICC) was used to measure intra- and inter-rater reliability
  - ICC: 0 to 1
  - 0.80: minimum acceptable
  - 0.90 and above: excellent agreement
  - (Shrout & Feliss, 1979)

Results

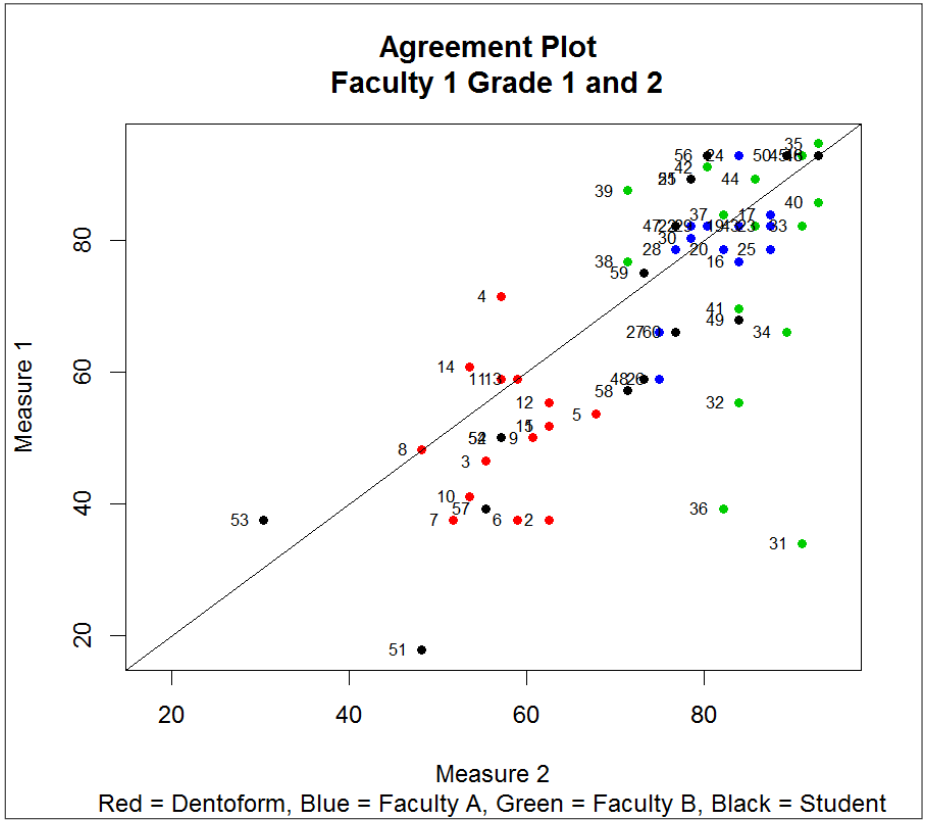
Visual vs Digital Grading Time



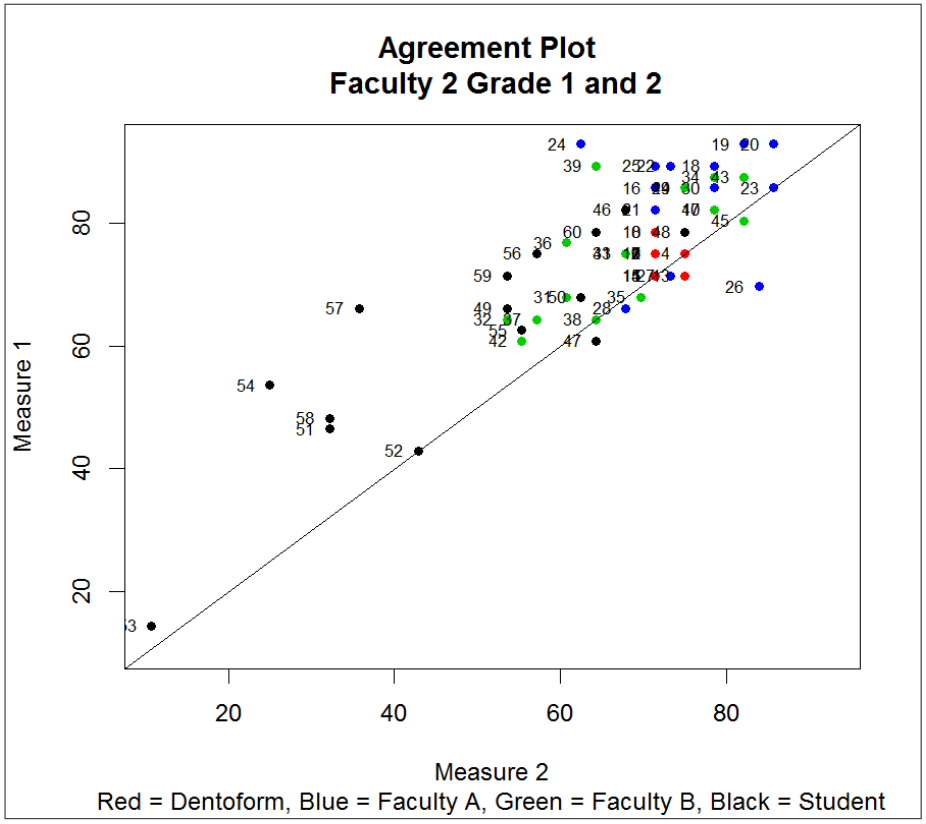
Visual Grade Percentages by Faculty

Table 1. Summary of Grade Percentages					
	Wax-up	Trial	Mean	Std Dev	Median
Faculty 1	Dentoform	1	50.71	9.78	51.79
		2	58.21	5.13	58.93
	Faculty A	1	80.36	8.88	82.14
		2	82.14	5.23	82.14
	Faculty B	1	75.36	19.04	82.14
		2	85.00	6.88	85.71
	Students	1	64.64	23.16	66.07
		2	69.64	16.85	73.21
Faculty 2	Dentoform	1	74.29	2.41	75.00
		2	71.90	1.26	71.43
	Faculty A	1	84.05	8.55	85.71
		2	75.95	6.74	75.00
	Faculty B	1	75.24	9.87	75.00
		2	67.86	9.62	67.86
	Students	1	60.95	17.75	66.07
		2	48.81	18.23	53.57

Faculty intra-rater reliability

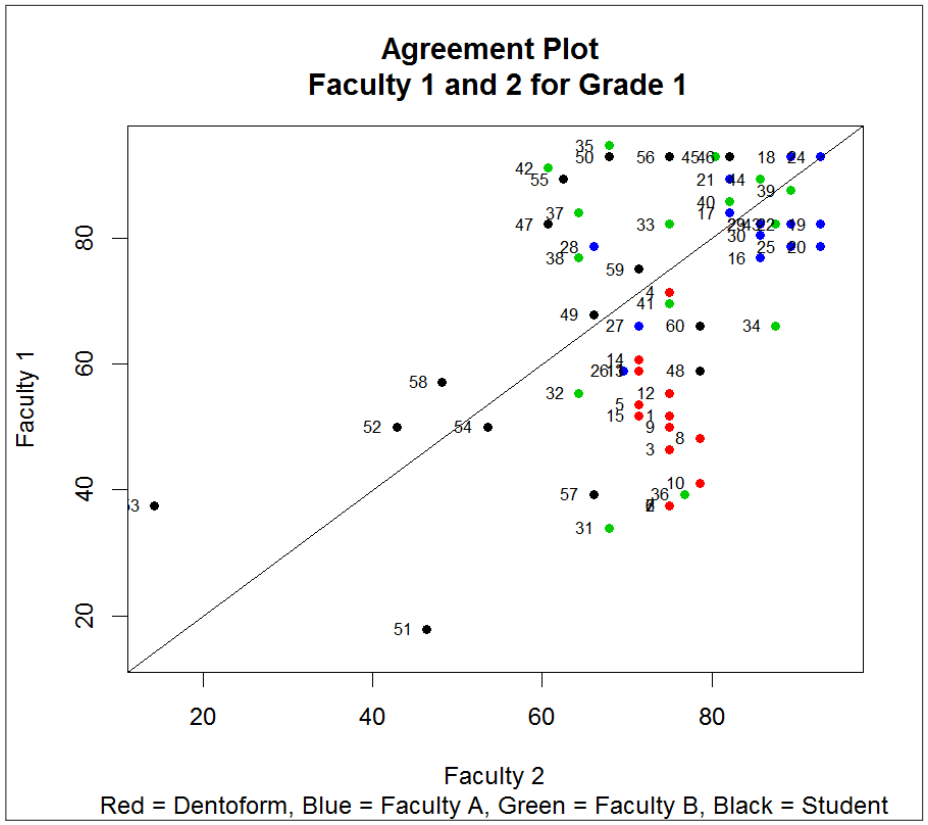


ICC: 0.65 / Spearman: 0.71



ICC: 0.71 / Spearman: 0.69

Faculty inter-rater reliability

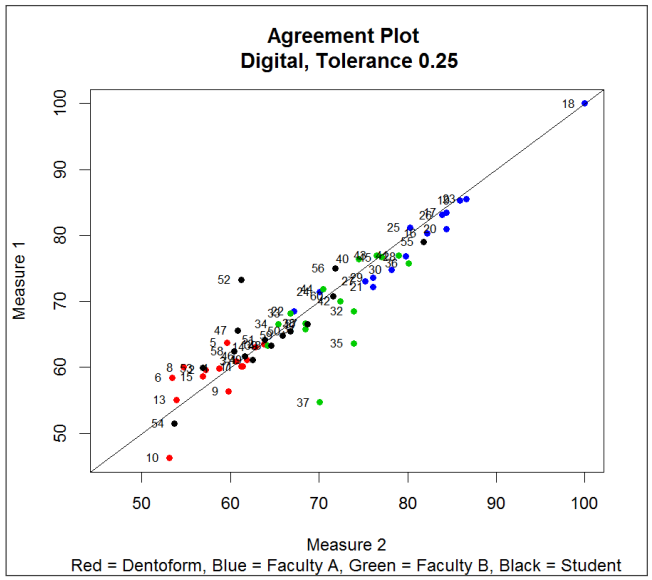


ICC: 0.39 / Spearman: 0.37

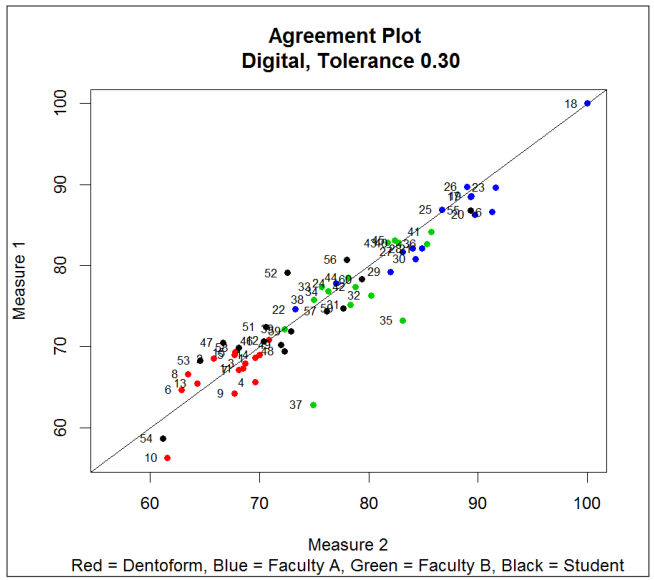
Digital Grade Percentages by Tolerance Level

Table 2. Summary of Digital Grade Percentages by Wax-up					
Tolerance	Wax-up	Trial	Mean	Std Dev	Median
0.25 mm	Dentoform	1	59.12	4.27	60.00
		2	58.61	3.55	59.60
	Faculty A	1	79.35	7.88	80.30
		2	80.69	7.79	80.30
	Faculty B	1	69.48	6.45	68.50
		2	72.09	4.90	72.40
	Students	1	65.65	6.76	64.80
		2	64.81	6.84	63.90
0.30 mm	Dentoform	1	66.69	3.42	67.30
		2	67.11	2.83	67.80
	Faculty A	1	84.97	6.21	86.30
		2	86.37	6.40	86.70
	Faculty B	1	77.41	5.56	77.40
		2	79.37	4.06	78.80
	Students	1	73.07	6.49	71.90
		2	72.80	6.82	72.30
0.35 mm	Dentoform	1	72.66	3.31	73.30
		2	74.02	2.58	75.00
	Faculty A	1	89.04	5.21	90.10
		2	90.43	5.27	91.70
	Faculty B	1	83.33	4.43	83.30
		2	84.95	3.52	85.10
	Students	1	79.40	6.06	78.50
		2	79.35	6.42	78.80

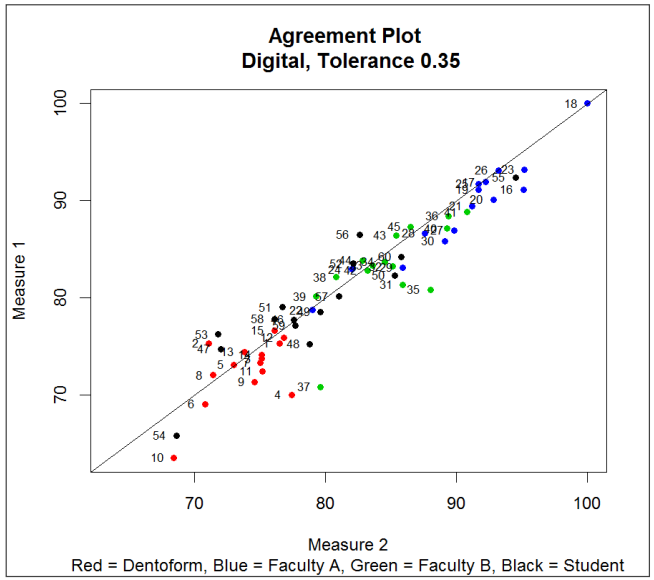
Digital intra-rater reliability



ICC: 0.93 / Spearman: 0.92

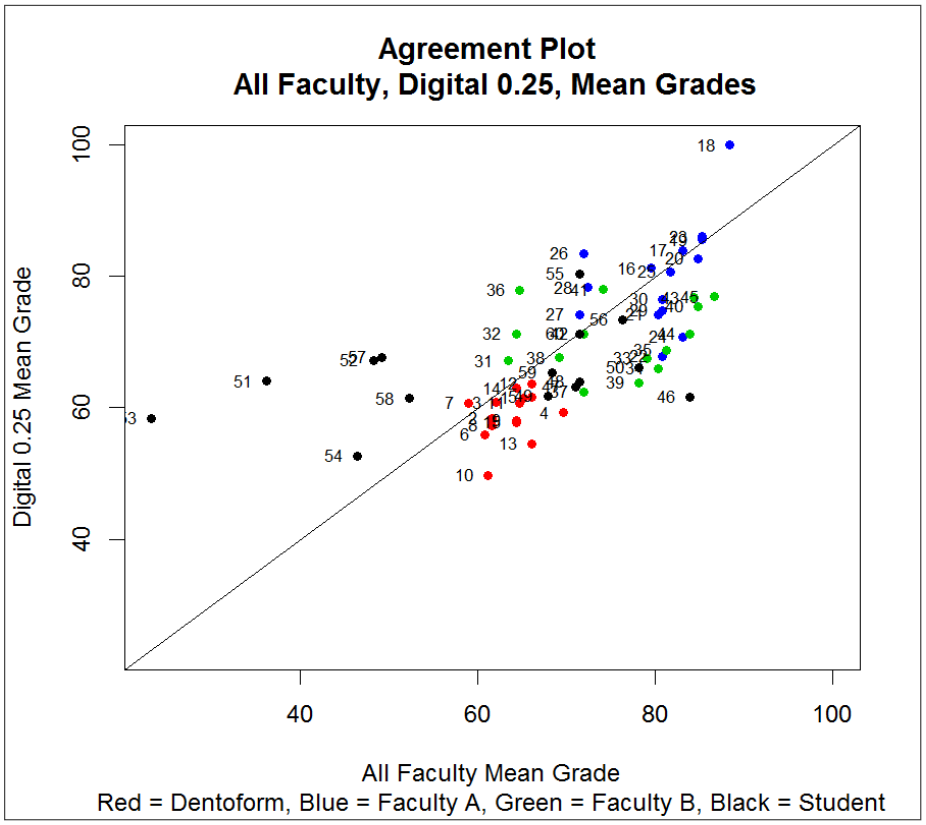


ICC: 0.94 / Spearman: 0.93



ICC: 0.94 / Spearman: 0.94

Correlation of visual and digital grading



ICC: 0.54 / Spearman: 0.68

Conclusions

- Visual grading is limited by modest intra-rater reliability and low inter-rater agreement
- Digital grading is promising showing excellent intra-rater reliability and correlation
- Correlation for visual and digital grading is modest, partly supporting the potential use of digital technology in dental anatomy grading

Future Directions

Proper planning for implementation of digital technology

into dental anatomy curriculum,

1. To supplement visual grading
2. Provide immediate feedback to students
3. Reduce workload of faculty

Thank you!

soran-kwon@uiowa.edu

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