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

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Abstract: The use of computers to aid in instruction and help decrease the subjective component of assessment is steadily increasing. One of the potential barriers to the effective utilization of CAD/CAM technology for assessment purposes is the efficient scanning of the teeth being used for comparison. The purpose of this pilot study was to determine if the use of different typodonts, of the same make and model, has any significant effect on the percent comparison results when using E4D Compare. Tooth #30 was prepared by a faculty member to represent what dental students at Georgia Regents University are taught as the ideal preparation for a full gold crown. Ten typodonts of the same make and model were selected for comparison. Three different examples of students’ preparations were scanned and compared to the ideal preparation. Each of the three student preparations was subjected to ten trials (occasions), one for each typodont, at five tolerance levels: 0.1 mm, 0.2 mm, 0.3 mm, 0.4 mm, and 0.5 mm. The intraclass correlation coefficient (ICC) was used to measure the intrarater agreement among the typodonts at the various tolerance levels. The agreement coefficients (0.971-0.984) indicated very little variability attributable to the use of a different typodont. The high agreement coefficients achieved using different typodonts of the same make and model provide evidence for the interchangeability of typodonts when assessing a student’s performance in the preclinical simulation environment.

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Dental schools use a variety of methods for the assessment of students’ performance when preparing typodont teeth in the preclinical simulation environment. Some schools will have one or more faculty members look at the preparation and assign it a grade based on their subjective evaluation of the entire effort. Many others assign the assessment of various aspects of the preparation to specific faculty members. The faculty member grades his or her assigned section and then passes the preparation to another faculty member who assesses another section. After all sections have been evaluated, a final overall grade is assigned based on the cumulative assessment of the various sections and the relative weights apportioned to each. Calibration of individual faculty members is imperative in order to diminish the impact of subjectivity, which is inherent in whatever assessment methodology is employed.1-6 Students and faculty members alike have expressed an interest in, and in some cases a preference for, the use of computerized assessment.7-11 Others have postulated that truly accurate feedback will not be achieved until the human element has been removed.12 While some may lament the use of computers in education and question their validity, their use to aid in instruction and help decrease the subjective component of assessment is steadily increasing.7,13 Before the implementation of any assessment methodology, it must be valid, reliable, and reproducible. In addition to these parameters, in order to implement the assessment modality in a dental school environment, with upwards of 50 to 100 (or more) students per class, it must also be feasible. Feasibility has been described as related to “barriers that prohibit the utilization of the technology, technique, or material, even if it is reliable and effective.”10

One of the potential barriers to the utilization of computer technology for assessment purposes is the efficient and effective scanning of the teeth be-
ing used for comparison. The aim of this pilot study was to determine if the use of different typodonts, of the same make and model, had any significant effect on the percent comparison results when using E4D Compare version 2.0 (Richardson, TX, USA). We asked if the teeth can be left in the typodont in which they were prepared when grading is accomplished, or does it require removal of the teeth and placement in a standard typodont or special “jig.” Our research hypothesis was that using different typodonts, of the same make and model, when comparing student preparations to the ideal preparation would not result in significant differences in percent comparison results.

Methods

This study received approval from Georgia Regents University Institutional Review Board. Using a Kilgore dental typodont (Kilgore International, Inc., Coldwater, MI, USA) made specifically for the Georgia Regents University (GRU) College of Dental Medicine, tooth #30 was prepared by a faculty member to represent what dental students at GRU are taught as the ideal preparation for a full gold crown. The same types of typodonts and teeth were utilized by the students to prepare tooth #30 to receive a full gold crown. Ten different typodonts were then selected for comparison: five were brand new, and five were typodonts that had been used by students in preclinical courses for a number of years.

To confirm the accuracy of the process, an ideal tooth preparation was compared to a second scan of the same ideal tooth preparation. E4D Compare version 2.0 has an auto-align feature that uses a multitude of similar points from the digital images of two typodonts to secure a precise alignment. It is important to capture enough surface area beyond the tooth or teeth one is comparing to ensure proper alignment. The E4D training manual recommends scanning one to two teeth beyond the tooth or teeth of interest, in both the mesial and distal direction.

Using the Nevo scanner and E4D Compare version 2.0, the ideal tooth was scanned, aligned, and compared to a previous scan of the ideal preparation. The same tooth #30 was then removed from the first typodont and placed consecutively into the second through tenth typodonts. Ten trials (occasions) were conducted, one for each typodont, at five tolerance levels: 0.1 mm, 0.2 mm, 0.3 mm, 0.4 mm, and 0.5 mm. Figure 1 shows the ideal tooth compared to a second scan of the same tooth in the same typodont. A tolerance level of 0.12 mm was utilized resulting in a

![Figure 1. Ideal preparation compared to second scan of ideal preparation at 0.12 mm tolerance level](image-url)
99% comparison. In this example, a tolerance level of 0.13 mm resulted in a 100% comparison. This means that, for this example, at somewhere between 0.12 mm and 0.13 mm of tolerance, the digital images, and therefore the preparations, are to be considered 100% the same.

Following this verification of accuracy, three examples of students’ preparations were scanned and compared to the ideal preparation. As with the initial comparison, each of the three teeth was subjected to the ten occasions, each at the five tolerance levels. The data resulting from this assessment were then compared to data retrieved from our other study to determine the average correlation of the student’s preparation with the ideal. The intraclass correlation coefficient (ICC) was used to measure intrarater agreement among the typodonts at the various tolerance levels. The method of Gilder et al. was used to estimate each ICC.

Results

When we compared the ideal preparation to separate scans of itself using the ten typodonts, we discovered that 100% correlation using E4D Compare (version 2.0) was realized at an average tolerance level of 0.173 mm (Table 1). This was surprisingly close to the 0.163 mm tolerance level identified in a previous study. At the 0.1 mm tolerance level, the average correlation was 98.5%. Figure 2 shows the combined agreement coefficients achieved from the three student preparations using the ten typodonts. The agreement coefficients of these comparisons (0.971-0.984) indicated very little variability attributable to the use of a different typodont. In general, an ICC of 0.75 or greater indicated adequate agreement.

Table 1. Percent comparison of ideal tooth preparation to itself at various tolerance levels

<table>
<thead>
<tr>
<th>Tooth</th>
<th>Dentoform Study (Ideal)</th>
<th>0.1 mm</th>
<th>0.2 mm</th>
<th>0.3 mm</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideal</td>
<td>LF5</td>
<td>97%</td>
<td>100%</td>
<td></td>
<td>0.146</td>
</tr>
<tr>
<td>Ideal</td>
<td>LF16</td>
<td>88%</td>
<td>100%</td>
<td></td>
<td>0.166</td>
</tr>
<tr>
<td>Ideal</td>
<td>LF80</td>
<td>77%</td>
<td>98%</td>
<td>100%</td>
<td>0.225</td>
</tr>
<tr>
<td>Ideal</td>
<td>LF80</td>
<td>84%</td>
<td>99%</td>
<td>100%</td>
<td>0.225</td>
</tr>
<tr>
<td>Ideal</td>
<td>LF4</td>
<td>92%</td>
<td>100%</td>
<td></td>
<td>0.148</td>
</tr>
<tr>
<td>Ideal</td>
<td>N1</td>
<td>85%</td>
<td>100%</td>
<td></td>
<td>0.155</td>
</tr>
<tr>
<td>Ideal</td>
<td>N2</td>
<td>86%</td>
<td>100%</td>
<td></td>
<td>0.154</td>
</tr>
<tr>
<td>Ideal</td>
<td>N3</td>
<td>88%</td>
<td>100%</td>
<td></td>
<td>0.148</td>
</tr>
<tr>
<td>Ideal</td>
<td>N4</td>
<td>90%</td>
<td>100%</td>
<td></td>
<td>0.17</td>
</tr>
<tr>
<td>Ideal</td>
<td>N5</td>
<td>90%</td>
<td>100%</td>
<td></td>
<td>0.17</td>
</tr>
</tbody>
</table>

Figure 3 shows the interrater agreement coefficients of the same preparations across the five tolerance levels using data from our other study. Those data were derived from five faculty members scanning and comparing the three preparations using the same typodont. The agreement between the averaged correlation percentages at each tolerance level was consistent with the accuracy of the E4D percentages achieved from the scans utilizing the different typodonts (Table 2).

Discussion

Our current method of assessment of student practical examinations at GRU includes the division of tooth preparations into various areas of concentration, with specific faculty members responsible for the grading of one particular area. This system has previously been referred to as component or checklist scoring. Following completion of the competency examination, the typodonts were collected and taken to a separate room to be graded. This is where the faculty members, through visual inspection, employ their clinical expertise and experience to assign a numerical value to their assessment of a student’s performance. This is an arduous and time-consuming process. Once graded, the scores were recorded, and the typodonts were returned to the students. The turnaround time for the grading process can be as short as two days and as long as four days, depending on the schedule and on which day of the week the examinations are administered.

In order to compare a student’s preparation to the ideal, using E4D Compare version 2.0, one must have a digital scan of the ideal preparation and a digital scan of the student’s preparation. The same
for their practical examinations, they will be able to perform the scan of their practical examination preparations prior to submitting them for grading. The subsequent comparison of this scan to the already scanned ideal preparation takes an additional two to three minutes. The simplicity of the scanning and comparisons goes a long way towards decreasing the turnaround time of the grading process.

digital scan of the ideal can, and should, be used for comparison with all of the students’ preparations. This process requires the scanning of each and every student’s preparation. Once proficient with the scanning process, an individual can scan the area of the typodont pertinent to the specific tooth or teeth in less than a minute. Assuming students will be using this technology for learning purposes as they prepare

**Figure 2. Intrarater 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. Interrater 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.
The reliability of the comparison is paramount to the viability of the process, and the accuracy of the overlay (or superimposing of models) defines the reliability. Utilizing the same dentoform or creating a jig to help standardize the scanning process would necessitate the removal of each tooth from its original dentoform and the replacement of each tooth into the dentoform or jig. Not only does the exchanging of teeth increase the amount of time each test will take, it also creates its own source of variability (e.g., do all teeth get seated in the new dentoform or jig in exactly the same way?). It also complicates the evaluation of other aspects of the examination not presently within the capability of the current E4D technology (e.g., damage to adjacent teeth or surrounding tissues). Inconveniences such as this can cause an educator to forgo the benefits of any given technology and revert to the more comfortable, more manageable, system previously used. The consequences of this are that, although the system is used initially with great enthusiasm, later on it may only be used sporadically, with preference given to a rough visual assessment.16

Another option would be to scan each tooth in the dentoform in which it was originally prepared. This would negate the potential variability introduced with the exchanging of teeth and also allow for the visual examination of the aspects of the preparation not available within the capability of current technology. As an added benefit, it may also decrease the grading time.

This study is one of several designed to highlight the potential of using CAD/CAM technology as an adjunct to the clinical and preclinical education of dental students. In other studies, we have investigated the reliability of using CAD/CAM technology in assessing crown preparations,10 the effectiveness and feasibility of using E4D technology as a teaching tool,17 and the relative inter- and intrarater reliabilities using different versions of E4D Compare.14 The results of these studies have indicated a high level of accuracy and dependability for the technology, but a less than overwhelming student participation rate when given the opportunity to utilize the technology to improve performance in practical examinations. This finding has caused us to conclude that the results acquired through the use of the digital comparison of students’ preparations to the ideal must somehow be incorporated into their assessment in order for them to actually implement it into their learning process and subsequently benefit from the potential this technology has to offer. While these studies have been limited to the comparison of crown preparations, similar comparison can be accomplished with other preparations as well (inlay, onlay, Class II, etc.) as long as a digital scan of the ideal preparation of the same type can be obtained.

The primary shortcoming of this study was the limited sample size. It should be noted, however, that we have been interchanging typodonts and teeth for various reasons for a number of years and have not noticed any unfavorable results. This study was conducted to systematically examine the phenomena that we had experienced with regard to the use of different typodonts. The results of this study provide justification for our scanning the students’ practical examination teeth in their own typodonts and then comparing those to a scan of an ideal preparation of the same type can be obtained.

The primary shortcoming of this study was the limited sample size. It should be noted, however, that we have been interchanging typodonts and teeth for various reasons for a number of years and have not noticed any unfavorable results. This study was conducted to systematically examine the phenomena that we had experienced with regard to the use of different typodonts. The results of this study provide justification for our scanning the students’ practical examination teeth in their own typodonts and then comparing those to a scan of an ideal preparation taken from a different typodont of the same make and model.

Another limitation of this study is that all of the scanning of the typodonts and comparisons of the digital images were done by one individual. This factor has the potential of introducing bias into the process depending on the ability of the investigator to perform the necessary steps required for accurate scanning and comparisons. One of our other studies indicated that inter- and intrarater reliability results were independent of the individual performing the scanning and/or digital comparisons.14 Given this consideration, the results of this study are also independent of the individual performing the scanning and/or digital comparisons.

### Table 2. Reliability of student’s preparations at various tolerance levels

<table>
<thead>
<tr>
<th>Tolerance</th>
<th>0.1 mm</th>
<th>0.2 mm</th>
<th>0.3 mm</th>
<th>0.4 mm</th>
<th>0.5 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability: different typodonts</td>
<td>0.971</td>
<td>0.984</td>
<td>0.973</td>
<td>0.984</td>
<td>0.975</td>
</tr>
<tr>
<td>Reliability: same typodont</td>
<td>0.972</td>
<td>0.980</td>
<td>0.992</td>
<td>0.986</td>
<td>0.973</td>
</tr>
</tbody>
</table>

Note: Top row (different typodonts) presents results from this study; bottom row (same typodont) presents results of five faculty members from Callan RS, Cooper JR, Young NB, et al. Inter- and intrarater reliability using different software versions of E4D Compare in dental education. J Dent Educ 2015;79(6):711-8.
Conclusion

The results of this study supported our research hypothesis. The high agreement coefficients achieved using different typodonts of the same make and model provided convincing evidence for the interchangeability of typodonts when assessing a student’s performance in the preclinical simulation environment. The confirmation of this study, combined with what was discovered in other studies, permits us to investigate the use of E4D Compare as an instrument for assessment of students’ performance in the preparation of a typodont tooth #30 for a full gold crown preparation.

Acknowledgments

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REFERENCES