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Computer-assisted evaluation and feedback of a complete student class for preclinical tooth preparation

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1 | PROBLEM

Motor skills for fixed prosthodontics are developed through preclinical practical tooth preparation. Evaluation and feedback are key elements for students and teachers to monitor the evolution of dental skills on an individual and/or group level, on a one-time assessment or over an academic year.^{1,2} The evaluation of tooth preparations performed by preclinical students is carried through two approaches.

The first one is a rubric-based assessment that is more reliable than a simple glance and grade method.² It has also the advantage of identifying the areas of interest on the preparation to allow an informative feedback.¹ However, the rubric system assessment does not provide a visual feedback.

A more recent approach using computer-aided design software allows a better appreciation of the result. But this approach is not compatible with use on a full class of students in routine because of the long scanning time^{1,3,4} and the very high cost of the equipment.^{3,5} This method is used to give immediate feedback and does not have the possibility of reviewing it at home. There currently is no feedback system that combines the two approaches mentioned above.

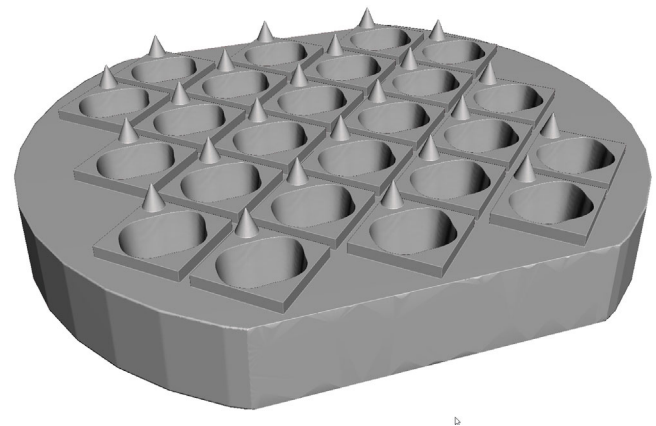


FIGURE 1 Scanning support containing 24 sockets. References consisting of cones and promontories enable each scanned tooth to be individualized and aligned to reference tooth.

2 | SOLUTION

A hybrid assessment solution was tested combining visual feedback and a rubric system on 69 ivory first left molars (ANA 4; Frasco, GmbH) prepared by the students. A support was edited and 3D printed that was created to hold 24 teeth with flat areas allowing retention by a tabletop scanner fixture (Figure 1). For collaborative purposes, the 3D support files (Standard Tessellation Language) are available. Instead of scanning the prepared teeth

Thomas Truchetto and Jean Dumoncel contributed equally to this work

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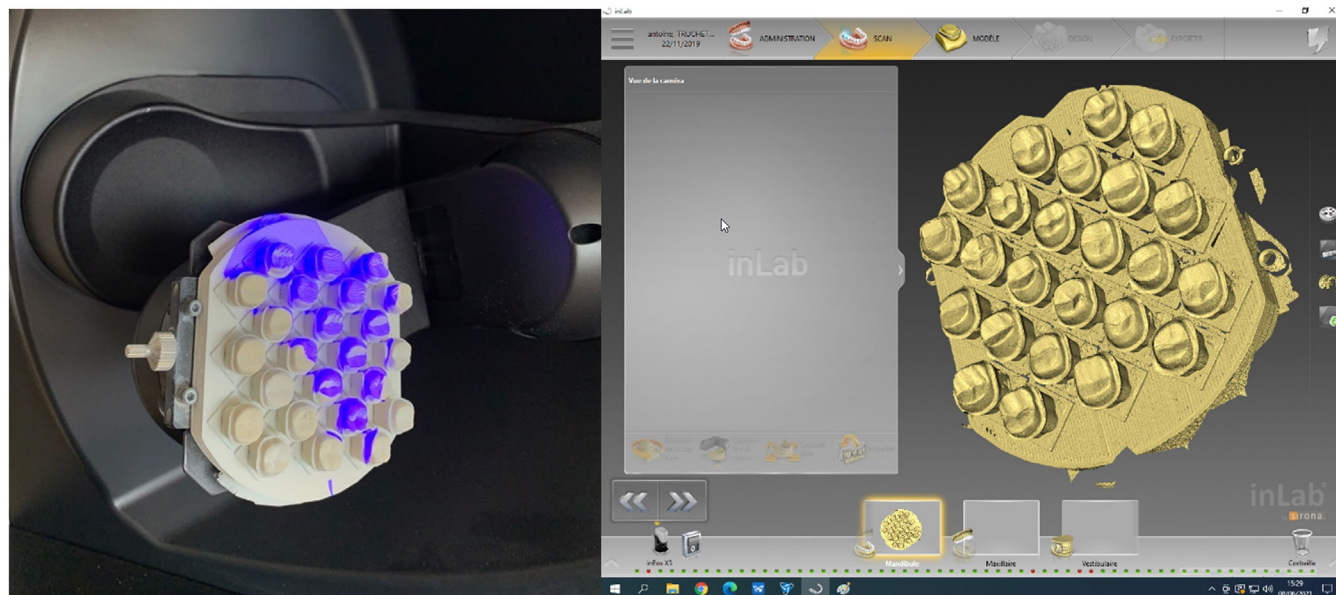


FIGURE 2 Automated optical scan of the base containing 23 preparations and one unprepared tooth with the inEos ×5.

individually, we scanned 24 teeth for each acquisition to save time (InEos ×5; Dentsply Sirona, Inc) (Figure 2). The surfaces were segmented, registered, and compared with a non-prepared tooth using free 3D computer graphics software (MeshLab, Deformetrica). The procedure was partially automated by a code edited in Python (Python 3.7.9.)

In practice, in a reasonable amount of time, after scanning all the preparations, the program could generate individual files containing visual feedback to assist in scoring with rubric system on training template. Using a laboratory scanner is relatively less expensive than an intraoral scanner because only one single machine is needed.

3 | RESULTS

Total 69 coronal-peripheral dental preparations were digitized and analyzed by automated image processing to provide an evaluation aid in a cumulative time of 97 min. The output of the computer program is a document with morphometric visuals and values for the preparation reduction achieved. This document was intended for the student's feedback and self-assessment, and for the teacher to monitor the results and grade the students (Figure 3). Each feedback consists of 3D view of the prepared tooth, values for prepared volume and deformation distance,

and a rubric scoring system for self-evaluation or teacher evaluation.

An illustrated support with the grading rubric produced within a short period of time appears to be an informative solution on which teachers and students could discuss. The teacher could obtain a summary document at the class scale, allowing him/her to target the students in difficulty, to pilot his/her teaching according to the defects mostly encountered, or to make intra- and inter-class comparisons. With this new hybrid approach, future studies could evaluate students' and teachers' perceptions of this innovation.


AUTHOR CONTRIBUTIONS

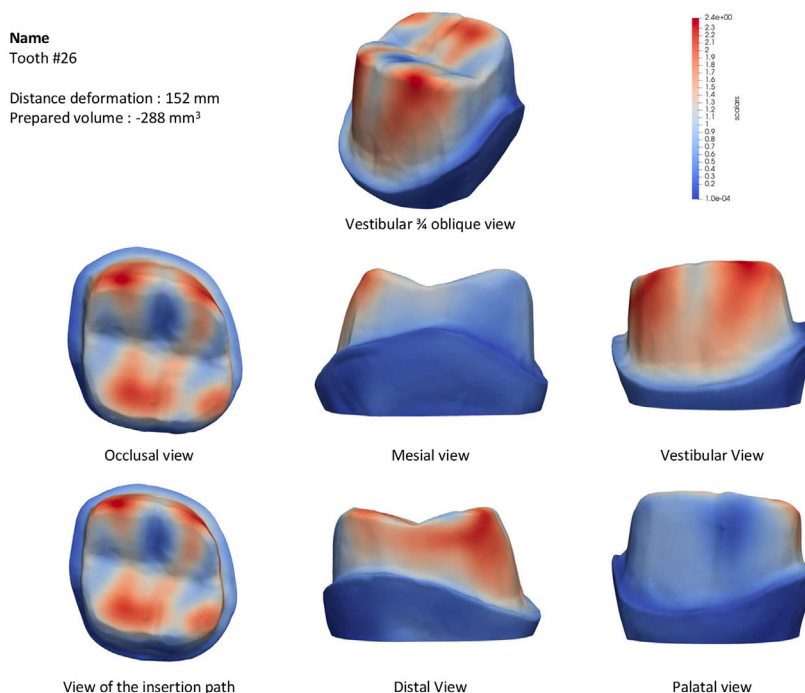
Thomas Truchetto: investigation and writing—review and editing. Jean Dumoncel: methodology and software. Cathy Nabet: supervision and writing—review and editing. Antoine Galibourg: conceptualization, project administration, and writing—original draft.

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Rubric scoring system for an all-ceramic crown preparation.

Parameter	1.5 points	1 point	0.5 point	No points	Score
Occlusal Reduction	<i>Optimal reduction</i> Supporting areas or porcelain = 1.5-2.0 mm	<i>Moderately under-reduced</i> Supporting areas or porcelain <1.5 mm	<i>Moderately over-reduced</i> Supporting areas or porcelain >2.5 mm	<i>Severely over-reduced or under-reduced</i> Supporting areas >3.0 or <1.0 mm Non-supporting areas >2.5 mm or <0.5 mm	
Axial reduction	<i>Optimal reduction</i> 1.5-2.0 mm and Rounded line and point angles	<i>Moderately under-reduced</i> <1.5 mm or Lack of rounded line or point angles	<i>Moderately over-reduced</i> 2.5 mm	<i>Severely over-reduced or under-reduced</i> >2.5 mm	
Taper	<i>Optimal taper</i> Retentive walls have 6° of taper	<i>Under- or Over-taper</i> Near parallel or over-tapered on mesial or distal (>8° <16°)	<i>Moderately Under- or Over-taper</i> - Undercuts visually present or - Over-tapered on buccal or lingual (>8° <16°)	<i>Severe Under- or Over-taper</i> - Severe undercuts present or - Severe over-tapered on any axial surface (>16°)	
Margin placement	<i>Optimal margin placement</i> Margins extended to specified target	<i>Over- or Under-extended</i> - < 0.5 mm subgingival - < 1 mm supragingival	<i>Moderately Under- or Over-extended</i> - <1.0 mm subgingival - < 1.5 mm supragingival	<i>Severely Under- or Over-extended</i> - > 1.0 mm subgingival - > 1.5 mm supragingival	
Two plane reduction		<i>Proper planes</i> Providing adequate material bulk for strength/aesthetics	<i>Moderately improper planes</i> over-reduced or under-reduced	<i>Significantly improper planes</i> over-reduced or under-reduced	
Finish, margins and walls		<i>Optimal finish</i> - Margins and walls are smooth - Margins are continuous, well defined	<i>Moderate roughness</i> - Moderate roughness of margins and walls - Margins are moderately non-continuous, moderate lack of definition	<i>Significant roughness</i> - Significant roughness of margins and walls - Margins are non-continuous - Lack of definition of finish line	
Preservation of adjacent teeth		Adjacent teeth are unaffected	Adjacent teeth are minimally touched.	Adjacent teeth are abraded and flattened	
Time management		Student ends the examination on time	Student ends the examination 10-15 min late	Student ends the examination more than 15 min late	
Total score of 10					

FIGURE 3 Portable document format for individual feedback with preparation visualizations and a rubric scoring system from Habib.²

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